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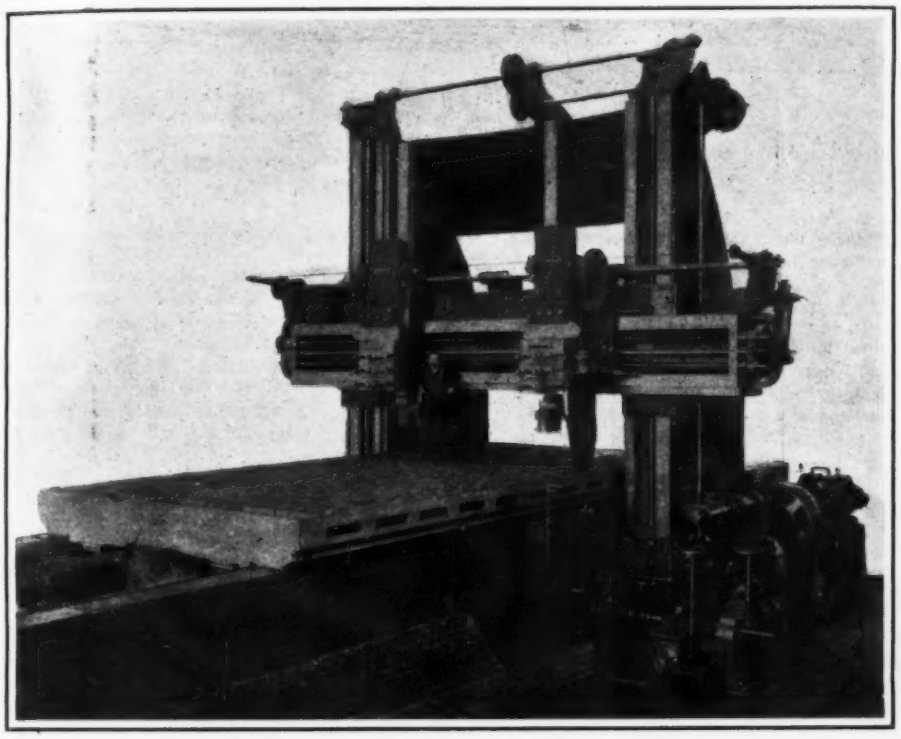

FIG. 1.—A GIGANTIC PLANER. WEIGHT 845,000 POUNDS. 207½ HORSE-POWER DEVELOPED BY FOUR MOTORS. NEW MOVEMENTS HAVE BEEN ADDED TO THOSE OF THE STANDARD MACHINE.

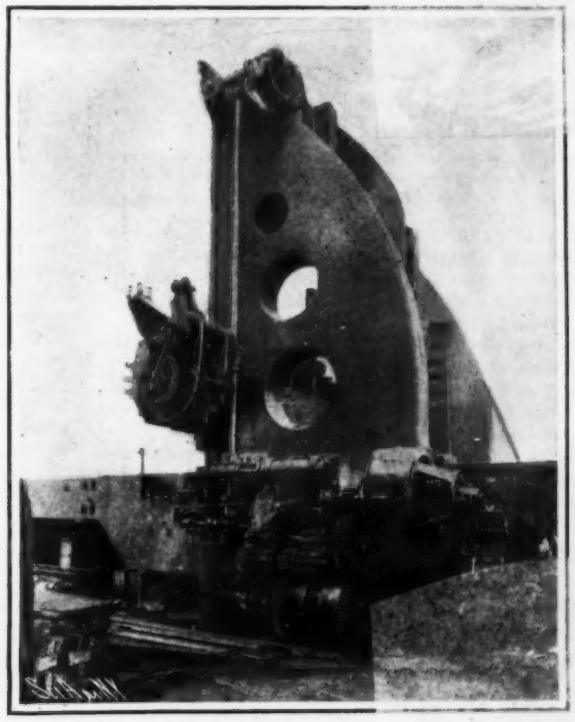

FIG. 2.—MAIN DRIVE BY 100-HORSE-POWER MOTOR THROUGH GEARING AND PNEUMATIC CLUTCHES.

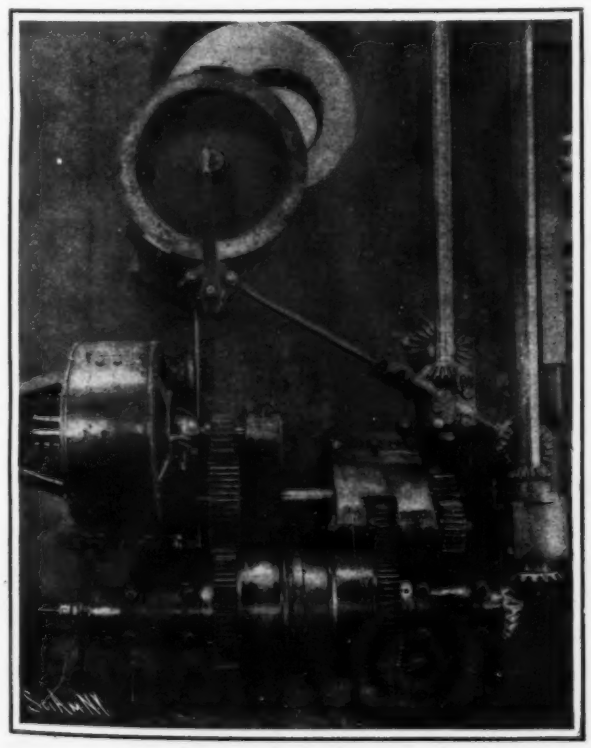

FIG. 5.—SLOTTER DRIVE SITUATED AT BASE OF LEFT-HAND UPRIGHT.

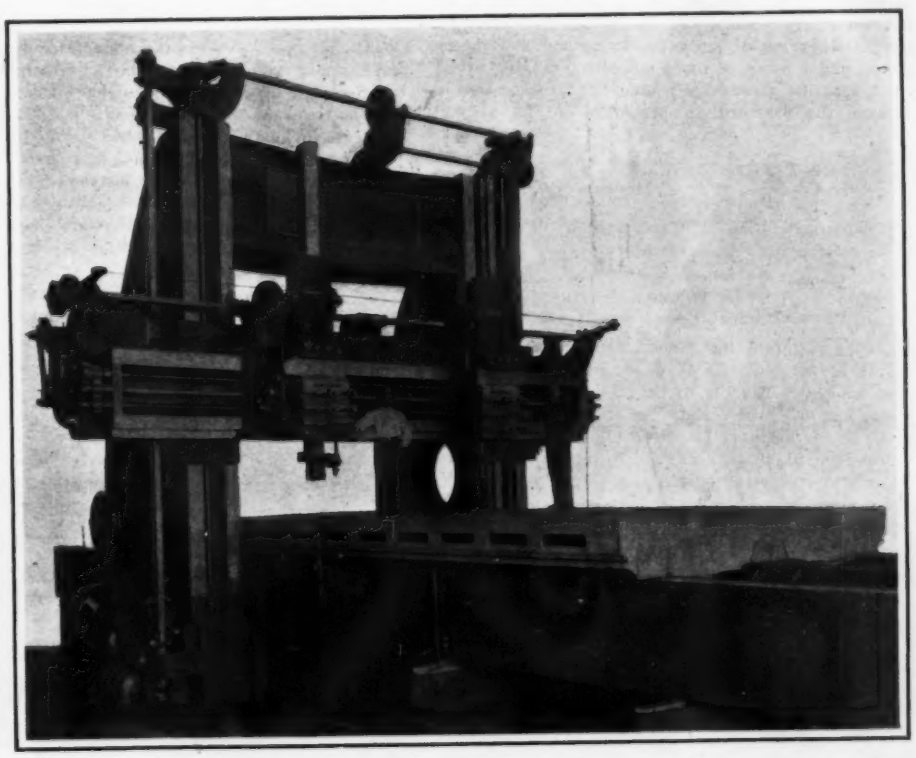

FIG. 6.—LEFT-HAND SIDE WITH MOTOR FOR SLOTTER BAR DRIVE AND PNEUMATIC CLUTCHES FOR SAME.

THE BIGGEST MACHINE OF ITS KIND EVER MADE.—[SEE PAGE 9.]

ELIMINATION OF FRICTION IN BALL BEARINGS.*

IMPORTANCE OF THIS QUESTION IN VIEW OF THE APPLICATION OF SUCH BEARINGS IN HEAVY WORK; SOURCES OF FRICTION ANALYZED.

BY J. F. SPRINGER.

THE elimination of friction from bearings in general is one of the most important topics that can engage the attention of the mechanical engineer. There are three main reasons for this: First, friction means abrasion of material, and the removal of material through abrasion is a very great disadvantage, inasmuch as it results in change of form and dimensions of the contacting parts, thus limiting their life. This

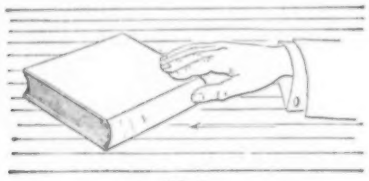

FIG. 1

is what we term "wear and tear." Second, the wearing away of this material requires power, and this power is worse than lost. And in the third place, friction sets up heat, which alone is often a most serious detriment.

Friction is of two kinds—*sliding friction* and *rolling friction*. Given two surfaces in contact, if there is such motion of one relatively to the other that the motion is parallel to the contacting surfaces, the result is sliding friction. Thus, as in Fig. 1, a book pushed across the surface of a table gives an example of sliding friction. And, furthermore, it is immaterial whether the book is pushed in a "right" line. Indeed (Fig. 2) it may be rotated so that every point of the surface of the book contacting with the table surface,

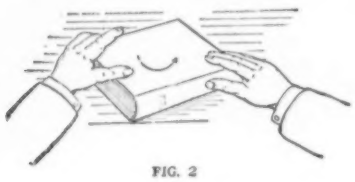

FIG. 2

except the center of rotation, moves in a circle, yet sliding friction results if these circles are in a plane parallel to the surface of the table. Such friction arises, of course, because the contacting surfaces are not absolutely smooth and so present to each other irregularities which mutually engage. When motion occurs under pressure these mutually engaging projections tend to abrade each other (Fig. 3). This is because the pressure, in proportion to its amount,

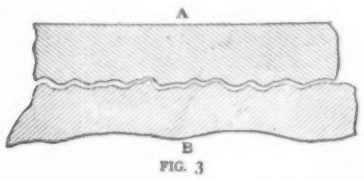

FIG. 3

tends to maintain the interlock. As stated, the removal of the particles is wear, requires power, and sets up heat. Thus is to be explained the excessive wear, loss of power, and rise of temperature which occur in the ordinary plain bearing.

However, the motion may not be in a direction parallel to the contacting surfaces, but may be such that there is an introduction and withdrawal of small projections, and this constitutes a form of rolling friction.

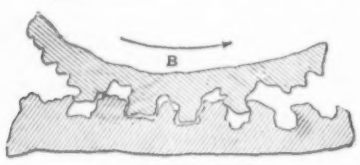

FIG. 4

It is due to the fact that the contacting surfaces are not absolutely smooth, but present to each other slight protuberances and depressions at a time when contact is maintained under pressure (see Fig. 4), as is the case with a wheel. Then there is the continual presentation of limited contact, combined with pressure, whether that which rolls is a ball or a roller. If the particles in actual contact are not adequately supported by others in their vicinity, small particles are detached from both contacting surfaces by a crushing process. Hardness combined with toughness (which is now possible to secure) goes far to eliminate this particular result of rolling friction. But the difference between sliding and rolling friction, as to abrading result, is well known to be very great. Indeed, a

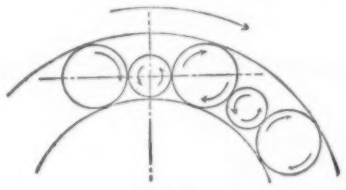

FIG. 5

mechanical engineer has achieved a tremendous practical result when he has succeeded in exchanging a sliding contact for a rolling one.

In this article it is proposed to deal with the elimination of friction from ball bearings. This is a matter of great practical importance for the reason that ball bearings are no longer merely the "playthings" of the mechanical engineer. They are, of course, still used in electric fans, carpet sweepers, and baby carriages, as there is no doubt of their suitability for these pur-

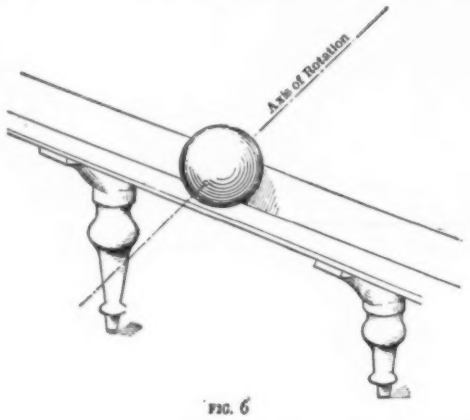

FIG. 6

poses; but they are being increasingly applied to heavy service, and the making of balls has greatly progressed, one at least of our manufacturing companies making and listing steel balls as large as 4 inches in diameter. Ball bearings are being applied to uses where the loads run to twenty-five and fifty tons. They are here to stay, because when constructed in accordance with designs available, with the accuracy possible, and with the steels obtainable, they are capable of tremendously exacting service. The experimental stage is rapidly being passed.

SOURCES OF FRICTION IN BALL BEARINGS.

There are at least four sources of friction in ball bearings. I enumerate them thus: (1) Rolling friction, arising from the fact that the parts in rolling contact are not absolutely smooth surfaces, and also from the circumstance that contact is so limited; (2) sliding friction, arising from the contact of balls with balls; (3) in four-point bearings, the conflict of the axis of rotation set up by the inner raceway with the axis of rotation set up by the outer raceway; (4) friction arising out of the surface-grind set up through compression between the ball and the bearing surface

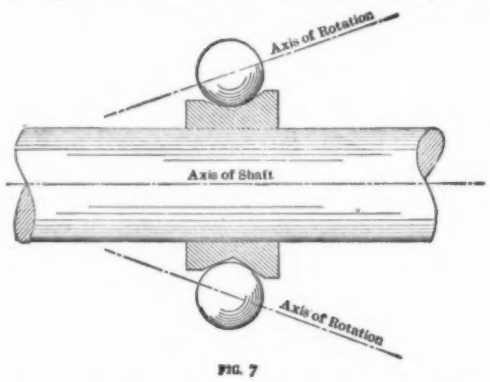

FIG. 7

at a time when this surface is not parallel with the instantaneous axis of rotation of the ball.

The first source of friction—that is, the friction

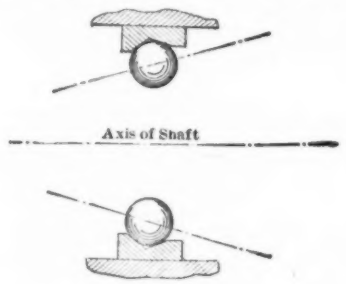

FIG. 8

arising from rolling contact—is largely eliminated by increasing the hardness and smoothness of the balls and raceways. The second source of friction—that which arises from the sliding contact of balls with balls—has attracted the attention of many inventors. The point should be emphasized that this friction is a "sliding" and not a rolling one. A little attention to the subject will convince one that the balls are rotating in opposite directions at the point of their mutual contact. It would seem that the only effective means of eliminating this source of sliding friction is the introduction of a ball or roller, or the equivalent, between consecutive bearing balls in such a manner that the separating means is not in pressure contact with

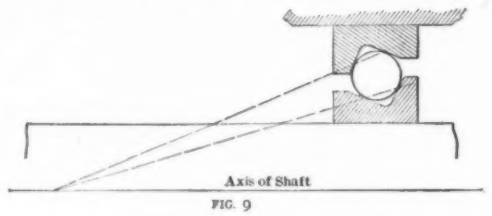

FIG. 9

either raceway. (See Fig. 5.) A separating device which does not roll would have but little effect, apparently, as the slide would still remain. It is not the writer's purpose to treat of the two preceding sources of friction in detail, but to devote the most attention to the third and fourth sources. Taking up the source of friction to which four-point bearings are subject, and which consists in the

CONFLICT OF THE AXES OF ROTATION,

a little consideration will convince one that when a ball is rolled in a V-shaped groove an axis of rotation is set up. That is to say, two surfaces of contact are sufficient to determine an axis of rotation. An example of this is seen when a ten-pin ball is rolled in the return trough (Fig. 6). Here an axis of rotation is immediately set up. Now this same thing is true whether the ball is rolled along a straight groove, as in the example just cited, or whether the ball is rolled in a circular groove. At every instant it has a certain definite axis upon which at that instant it may be regarded as rotating. Such a definite axis of rotation is set up by a V-shaped groove on a shaft, Fig. 7, and also a definite axis of rotation is set up independently by the V-shaped groove in the housing, Fig. 8. In a four-point bearing these two V-shaped grooves exist simultaneously. And so, in consequence, there result simultaneously the efforts of the two grooves each to

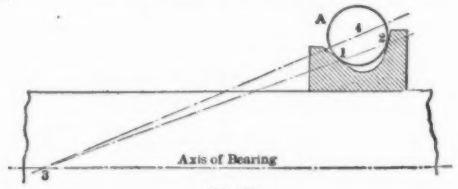

FIG. 10

set up its respective axis of ball rotation. It becomes, then, a matter of considerable importance that these two axes of rotation shall in reality not be two, but one single axis. That is to say, it is important that the axes should coincide (Fig. 9). Otherwise, there is a contest between the two separate axes, which will give rise to a sliding friction.

HOW TO FIND THE AXIS OF ROTATION.

It will be instructive to point out how the axis of

* Power (N. Y.)

rotation set up by the contacting surfaces of a V-shaped groove may be found practically. By referring to Figs. 10 and 11, it will be seen that the ball *A* contacts with the bearing ring at the points 1 and 2, Fig. 10, and at the points 5 and 6, Fig. 11. Draw a straight line through 1 and 2, or through 5 and 6, and prolong it until it intersects the axis of the bearing at 3. Draw a straight line through 3 and the center of the ball 4. This line 3—4 is the axis of rotation. It will readily be seen that in order to avoid conflict of the axes when *both* inner and outer V-shaped grooves occur in one bearing it becomes necessary that the

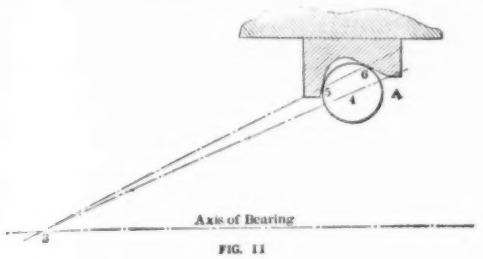

FIG. 11

lines 1—2 and 5—6, when prolonged, shall meet the axis of the bearing at the one point 3, Fig. 12.

Some years ago this matter was dealt with in effect by an Italian inventor named Casalegno. He seemed to think that when he got the lines 1—2 and 5—6 to intersect the axis of the shaft at the same point he had eliminated all sliding friction—at least, all sliding friction due to contact of balls with rings. He was in error as to this, as will appear in the sequel.

Before passing on to the next source of friction it will be instructive to call attention to an unnecessary restriction to which this same inventor thought it necessary to subject the three-point construction. He thought that when one of the bearing rings presented a single surface to the ball instead of a V-shaped groove, the prolongation of this single surface should pass through the point 3, Fig. 13. In this he was mistaken, in so far as the harmonization of velocities is concerned, for the following reason: *One* point of contact between a surface and a rolling ball is not of

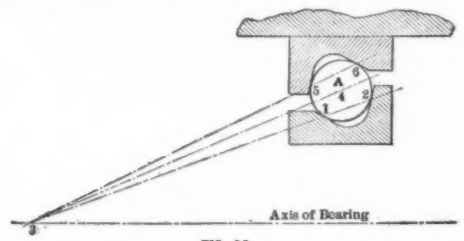

FIG. 12

itself sufficient to determine a definite axis of rotation. In fact, it harmonizes with any axis whatsoever. If one of the bearing rings, say the inner, has two points of contact with the ball, Fig. 14, and consequently determines a definite axis of rotation, the one point of contact between the outer ring and the ball will not set up an additional axis, but will accommodate itself to the one set up by the inner ring. And it does not matter where this point of contact of the outer ring is situated. The restriction that it should be so located that the tangent at this point would pass through 3 is unnecessary. In three-point bearings, then, the conflict of axes which we have been considering does not occur.

THE MOST SERIOUS SOURCE OF FRICTION.

Regarding the fourth source of friction—that which arises from the actual rotation of a ball relatively to the contacting surface—if steel balls and steel bearings could be made absolutely smooth and incompressible, and not subject to minute flakings arising from inadequacy of support, this trouble would not arise. As it is, however, the trouble exists and constitutes perhaps the most serious source of friction to which

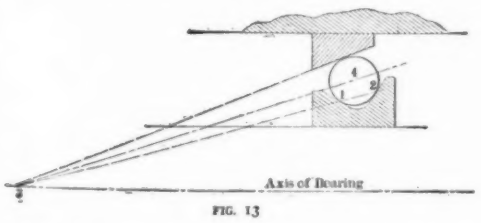

FIG. 13

ball bearings are liable. By referring to Fig. 15, which shows to a greatly exaggerated degree the compression between the ball and the race, it will be noticed that the line 1—2 is not parallel to the surface of contact, but makes an angle with it.

In order to comprehend clearly the source of friction which the writer is about to explain it will be necessary to understand somewhat the character of the line 1—2. The technical name for this line is the *instantaneous axis of rotation*. Its character is this: If we take our position on the bearing ring and, disregarding its motion, pay attention only to the motion of the ball relatively to this bearing ring, we shall observe that all points on this line 1—2 are quiescent, that the ball is in fact rotating about this line as an axis. This is the reason for calling the line an axis of rotation. But this axis of rotation is good for an instant only. As the ball rolls, there is a constant change of axis. It is therefore appropriate to call it the *instantaneous* axis of rotation, seeing that it is the axis for the instant only.

This rotation of the ball relatively to the contacting

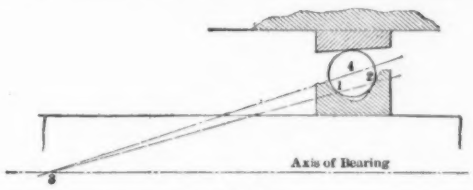

FIG. 14

FIG. 15

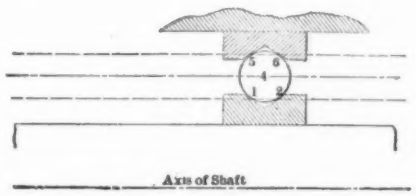

FIG. 16

surface is complicated with compression. By referring again to Fig. 15 it will be seen that all points of the line of contact 8—9, except 0, which is quiescent, are swinging in circles about the line 1—2. Thus, 8 swings in a circle whose center is 1′ and whose radius is 1′—8. That this gives rise to sliding friction is quite clear. That this friction is approximately proportional to the pressure *along* 1—2 would seem to follow as a consequence. It will be readily granted by those who have followed this discussion that here is a most serious source of sliding friction. It will be observed, however, that it disappears as the angle between 1—2 and 8—9 is diminished. It becomes very important then, from the point of view of the elimination of this source of friction, that this angle should be made as small as possible. The result of all this is that flat raceways are an absolute requirement. By

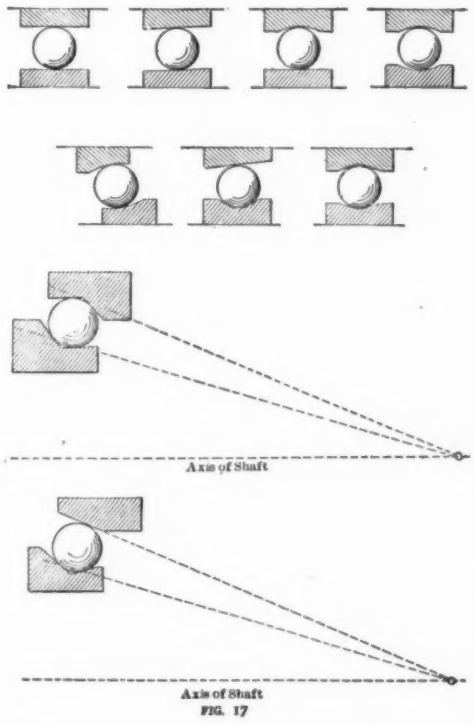

FIG. 17

flat raceways is meant raceways whose sides are parallel, or approximately so, to the corresponding instantaneous axis of rotation. Examples of such raceways are shown in Fig. 17. In contrast with these are shown in Fig. 18 examples of incorrect forms.

In applying these principles to the special cases where one instantaneous axis of rotation is parallel to the axis of the shaft, let it be noticed that this will have the effect of carrying the point 3, where the instantaneous axis and the axis of the shaft meet, off to infinity. This will result in requiring the other instantaneous axis to be parallel to the axis of the shaft. So also with the axis of rotation itself. This is brought out in Fig. 16. In such cases it is necessary that *all* bearing surfaces should be parallel, or approximately so, with the axis of the shaft, at least at the several points of contact.

Probably the great bulk of ball bearings, if we except a few styles made in the last few years, have been constructed on more or less erroneous fundamental principles. The time is at hand when a tremendous increase in the application of ball bearings to heavy machinery is about to take place. It is therefore important that the fundamental conditions should be discovered and made known. It is hoped by the writer that the present article is a serious contribution to this difficult subject.

THE ACTION OF STEAM IN CYLINDERS.

THOUGH Hirn, by his careful experiments and scientific investigation, may be admitted to have laid pretty firmly the foundation of the theory of steam action in a cylinder and to have thoroughly established the theory of cylinder condensation certain experimenters in Great Britain have for some time been seeking doubtful laurels in overturning Hirn's conclusions, or rather should we say in endeavoring to overturn them, for it cannot be said that any convincing figures have been advanced by the new school. Indeed, from figures which have appeared from time to time it may be said that the conclusions drawn by Hirn are

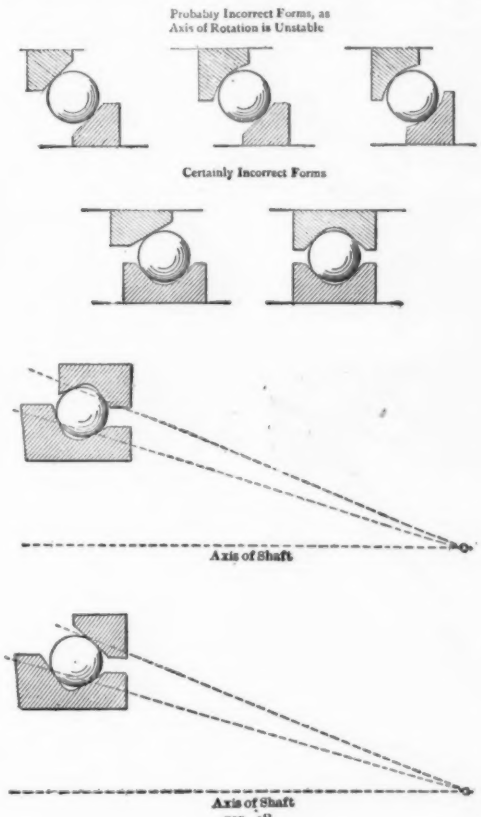

FIG. 18

strengthened rather than that the contentions of the new school are in the least borne out. Hirn, it is well known, argued that since the steam in a cylinder is constantly varying in pressure and therefore in temperature, the cylinder metal must be continually striving to attain the same temperature as the steam. The steam and the cylinder metal are but a very brief time in contact, and it is argued by the new school that this time is too short to produce the effects noticed, so the theory of leakage is advanced to explain the facts. A study of the indicator diagrams certainly gives no support to this hypothesis. The Engineer, of London, now comes forward and endeavors to show that even if the time of exposure of the steam to the cylinder surfaces is not sufficient to allow of the interchange of heat sufficient to produce the results so well known, it is possible that a film of water globules on the surface would do so. We admit that this is so and we see no objection whatever to this rendering of Hirn's theory. Indeed, we never knew an upholder of Hirn to omit the consideration of water action. Is not the cry for superheat simply an endeavor to abolish the film of water? Has it not always been held that if there be no water to re-evaporate there can be little cylinder cooling and so again still less water?

But granting that the metal surface reactions are intensified by water globules, we would have no one forget in this contention that when the gases from a boiler furnace pass over the heating surfaces of a boiler they do so at a high velocity, yet they lose their heat in an incredibly short space of time. Thus in the

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case of water-tube boilers half the heat of the gases is abstracted in the course of a passage of two or three rows of tubes. Why should the wet gas in a steam cylinder be less active in the interchange of heat than the dry, non-conducting gases of a furnace? We think that a little attention to this curious phase of the steam-raising problem may do much to clear up this interesting problem. We see nothing yet to push Hirn's theory off its pedestal, and we might add as another example of rapid interchange of heat, the rapid dearth of steam in the surface condenser. The instant formation of a good vacuum seems to us to prove that so far as regards moist steam the transfer of heat to or from metal of a different temperature hardly calls for much time.—Street Railway Journal.

ELEMENTS OF ELECTRICAL ENGINEERING.—VIII.

PRINCIPLES OF DIRECT-CURRENT MOTORS.—(CONTINUED.)

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1668, page 391.

IN the preceding chapter, an attempt was made to show that, in operation, a motor develops a counter electromotive force; that it is the difference between this and the applied electromotive force that determines the particular current consumed by the motor, and that far from being avoidable this counter action is an inherent and vital matter. In this chapter, further explanations will be made, also some statements as to the efficiency of operation, the factors that determine the regulating qualities of the motor and the method of connecting to the supply circuit.

If two identical dynamos be taken and driven at the same speed and in the same direction, they will both generate the same electromotive force, and corresponding brushes will be of the same polarity. In order to avoid considering as yet the method of energizing the field magnet, let the machinery be fitted with permanent magnets as shown in Fig. 31. If connected by wires, no current would flow, because the two electromotive forces would be just equal and opposite; current could be readily delivered to an exterior circuit—half coming from each machine. The case is like that of two steam boilers, at full pressure, being connected to the same outgoing pipes; steam would not pass from one boiler to the other, but from both to the engine. Imagining the + pole to be at the top brushes, as shown in the diagram, and the direction of rotation clockwise, as indicated by the upper curved arrow, now remove the exterior driving power from the right-hand machine. It would be found to continue to rotate, but at a somewhat reduced speed. A moment before, it was as much a generator as the other, but it has suddenly become an electromotor. The other could just as well have done the same. Although the speed is reduced there has nothing happened to change the polarity; the poles of the field magnet have not been altered, nor has the direction of rotation, and an application of the right-hand rule will still make the upper brush positive. In consequence of the lessened speed, however, the value of the electromotive force will be proportionately reduced, and therefore the higher electromotive force of the unchanged generator will succeed in sending some current through the circuit. If the curved arrows encircling the commutator represent the direction in which the e. m. f. is generated, that is, upward from — to + brush, they show that the current flows in the same direction in the generator as the e. m. f. acts, but in the opposite direction in the motor. With no load at all on the motor, the speed is a maximum, and the counter e. m. f. may almost equal the applied; current would be needed for no other purpose than to produce enough torque to overcome the friction of bearings, brushes, etc., and the loss due to eddy currents in armature core and polar faces. In a well designed motor this should not be over five per cent of the total current which the winding can readily carry. With the armature blocked so as to be incapable of rotation, the counter e. m. f. would necessarily be zero, and an enormous current would flow—quite beyond the capacity of the wires to endure. Safety fuses, or circuit breakers, are usually provided for such emergencies, to open the circuit and save the motor from "burning-out." Intermediate loads will allow the armature to rotate at such speeds as will allow just that difference to exist between the counter and the applied e. m. f. to determine the particular value of the current needed; this difference divided by the armature resistance will always equal the numerical strength of the current.

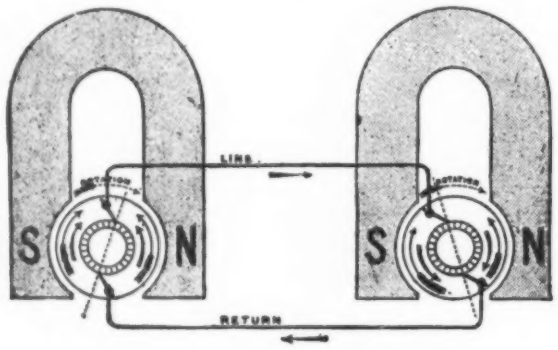


FIG. 31.

As early as 1850, Jacobi seems to have recognized this inherent analogy between a generator and a motor, and showed mathematically that the maximum output could be secured from such a combination when the c. e. m. f. was just one-half that of the generator, or, with identical machines, as given in Fig. 31, when the speed of the motor was one-half that of the generator. This is a law that has its counterpart in mechanical engineering—well illustrated by the impulse, or "Pelton," water wheel. If the blades on the periphery of the wheel are moving with a velocity just equal to that of the stream or jet of water, no torque results, for the water exerts on them no push; maximum speed, however, is attained. Power equals *speed* times *torque*, and if torque is equal to zero, no power is produced. If the wheel is prevented from rotating, the water dashes against the blades with the maximum impact, but with speed zero, the power is again zero. Anywhere between these two extremes the product of speed and torque will be a real quantity, and at a maximum when the load on the wheel is such that the speed of the blades is just one-half that of the water, and this is the condition of 50 per cent efficiency. With less load upon the wheel, the efficiency rises, and by being contented with a lower power from a given size of mechanism than might be, a user gets the benefit of more economical conditions of working. This principle has been of rather modern appreciation, and in the electric case, Jacobi's law of maximum output was tenaciously held for thirty years to mean that even if practical motors were constructed, they could not possibly return more than one-half of the energy that was supplied to them. An unfortunate corroboration of this theory was obtained from the early use of motors on series arc lighting circuits; the motors themselves were none too good, while the generators themselves, as explained in Chapter III., had, and still have, unavoidable conditions of low economy. With better motors operated on constant potential circuits, experimental evidence showed that 75 per cent to 85 per cent return was possible—in fact, regularly attainable, and that Jacobi's law of maximum output was not at all the law of maximum efficiency. Siemens formulated the true statement of the latter—that, neglecting frictional, etc., losses, the efficiency of the revolving member of a motor was directly proportional to its counter e. m. f., and that the real efficiency was simply expressed by dividing the counter by the applied e. m. f. Allowing for inevitable losses in armature and field, it is not now ordinary to allow motors to aim for a working efficiency of over 85 per cent, but the 50 per cent value is never utilized except when momentary loads of considerable severity are applied. A motor propelling a car up a short steep grade may, for a few minutes only, yield this maximum output, but the wires are insufficient to carry for a longer period the large current involved. The rapid heating due to such loads is permissible only in case the car is soon descending a grade, with consequent opportunity for the windings to become cooled.

A curious difference between generator and motor working is brought out by the relative position of the brushes on the commutator. As mentioned in earlier chapters, the armature currents in a generator act in such a direction as to necessitate the shifting of the brushes *forward* in the direction of rotation, the purpose being to secure an average position of non-sparking. For the same purpose, motor brushes need to be shifted *backward*. Reference again to Fig. 31 will show that this feature is included—the generator brushes being ahead of a vertical "neutral" line, those of the motor being as much behind a similar line. The reason is also apparent, for if current flowing in one machine in a certain direction requires forward shifting of the brushes, then in the other machine, through which the current is flowing in the opposite direction, the correction will be in the backward sense. In modern dynamos, the causes which produce sparking are so well understood and capable of such suppression as to allow the brushes to be set in about the theoretical neutral position, and yet give satisfactory commutation. Especially is this feature desirable in railway motors, in which shifting of the brushes with change of load or of direction of rotation would clearly be impracticable.

With two machines of identical construction, as shown in Fig. 31, the number of revolutions in a given time will always be less with the motor than with the generator, for the c. e. m. f. can never equal the applied. Slight changes can be made in the motor at will, which, though still complying with the last condition, will allow the speed to vary within very wide limits. Speeds below normal can be secured by inserting a resistance in the main circuit, thereby wasting a part of the pressure, and the c. e. m. f. which the armature must then generate is equal to the unwasted part. By weakening the field magnet, speeds above normal can be secured. This occurrence is rather startling to beginners in electrical engineering, but with proper limitations the truth can readily be comprehended. Experimental evidence is to be sought when the actual loads on the motor are light, or better still, when there is no load at all. It is certain that a generator with a weak field magnet will require a higher rotative speed to produce a given electromotive force than one with a strong field; in fact the e. m. f. will be directly proportional to the speed. The motor is a dynamo obeying the same law; with a certain e. m. f. applied to its terminals, the armature must rotate until its c. e. m. f. approaches that value, and in a weak field the speed at which it attains this result must be higher than in a strong field. A simple means then of varying the speed above normal is to have a rheostat so connected as to vary the current flowing in the field coils. Speed about 100 per cent above normal is about the limit of safety and of sparkless commutation. By the use of auxiliary poles, energized by the main current, and located midway between the main poles that are excited by the shunt winding, good commutation is retained well within the limits of mechanical considerations.

The tenacity with which the early engineers clung to series systems of distribution and connections of windings, is well illustrated in early motor practice. Still, there is a certain consistency in engineering methods, that is, if one part of a system requires series connections, the rest should be similar; for instance, if arc lamps are to be operated in series, as for street lighting, the generator should have a "series" field magnet, and any motors in the circuit should also have similarly wound fields. Or, if incandescent lamps are to be operated in multiple or parallel, each one forming an independent path, the generator may well be "shunt" wound, and motors on the circuit should have shunt field magnets. Since arc lighting circuits were for many years the only ones that extended any considerable distance from the stations, a large number of motors were used on them, thereby helping to provide a 24-hour load. Aside from the personal danger due to contact with wires at such

high voltages, there are serious defects in such a transmission in consequence of the extreme variations in the speed of motors with change of load. Each motor tries to run at such a speed that its c. e. m. f. will equal that of the generator; in reality a large number of such motors would be in series on the same circuit, therefore any one should normally run at such a speed as to generate only its proportionate part, and such a load assigned as to keep its speed at the desired value. If such an increased load was applied as to stall the motor, no harm would result, for by the automatic action of the regulator on the generator, the same current is always in circuit; if the load is reduced, the speed will increase, and such a contingency as the belt coming off would allow the armature to fly to pieces from excessive speed. Centrifugal governors were therefore applied, which would either gradually cut out the field magnet winding, or shift the brushes to such a point that no torque would be produced.

A great deal of the early popularity of the electric motor, following the establishment of "Edison" lighting companies, was due to Lieut. F. J. Sprague, who brought out the design shown in Fig. 32. Although the mechanical construction was good, the electrical circuits were the essential grounds of success. He was the first to employ shunt-wound field magnets and connected the machines to the constant potential (incandescent lighting) circuits instead of to those for constant currents (arc lighting). By this device, the field magnet was entirely independent of the varying loads upon the armature; with increase of load the retardation of speed was not serious, and if the entire load was suddenly thrown off, the increase in speed was hardly discernible. As compared with the erratic performances of series motors on arc circuits, the self-regulating properties of Sprague's shunt motors seemed like oil on troubled waters. The inventor went even further, and introduced the reverse of compound winding in the field magnets, and denoted it as "differential" winding. In reality, a compound-wound generator used as a motor illustrates the very device; but whereas, in the generator, the current flows through the series coils in the direction to assist the shunt, the reversed direction in armature of motor would mean also reversed direction in series coils, but unchanged direction in the shunt winding. The shunt would, therefore, be establishing a certain polarity of the field, while the series would tend to create reversed poles; the result would be a field magnet of strength proportional to the difference between the respective number of ampere-turns, and this difference would be the less in proportion to the current in the series coils and armature, i. e., proportional to the load on the motor. It has just been explained that a weakened field means increase of speed, but an increase of load demands decrease of speed, and Sprague so adjusted the relative strengths of series and shunt windings, that one of these factors just offset the other, resulting in an almost perfect uniformity in speed, quite independent of the load. The class of work that demands such a finesse in the uniformity of operation is so limited that differential motors are now not often seen. With modern low resistance armature windings, the actual variations in speed, due to extreme changes of load, are of small consequence. Oftener the opposite connections of the series coils are used, yielding a "cumulative" field, for enabling the motor to start under a heavy load. If left in circuit, the series portion of the winding would imitate the conditions of a plain series motor, i. e., produce variations of speed, inversely as the load, therefore, after starting, such coils would ordinarily be short-circuited through a single-pole switch. A shunt-wound machine has the same direction of rotation, whether used as a generator or a motor; a series-wound generator requires rotation in a certain direction, but as a motor, it revolves in the opposite direction. Therefore, if a compound-wound machine is used as a differential motor, the shunt winding, usually the stronger, will tend to produce rotation in one direction, but the series, in the other. At the moment of starting, such a rush of current will energize the series portion, as possibly to reduce the strength of field below the needed value; therefore, such series coils should be left short-circuited until full speed is attained. Then again, if in the ordinary running, a momentary heavy overload is applied, the series coil might actually preponderate, and reverse the motor. Such a case, however, would represent such a draft of current as to blow the fuses. Some of Sprague's early differential motors were, unfortunately, applied to elevator operation; for the reasons just enumerated their unfitness was apparent. In general, plain shunt-wound motors have been found to be eminently satisfactory for constant speed stationary machinery, plain series-wound ones for variable speed hoisting and traction work. The highly specialized design of the latter demands a special chapter for more adequate explanation, and still another for considering the appropriate regulating and controlling devices.

With shunt-wound motors, the starting devices are quite simple, and unless the case be one of some particular individual drive, regulating devices may be entirely absent. Merely a starting rheostat is needed in the armature circuit to prevent too great an initial rush of current, that might give an uncomfortable jerk to the machinery, throw off the belt, flash at the commutator, blow the fuses, burn out the windings, or disturb the rest of the system. Since the current that normally flows is equal to the difference between applied and counter e.m.f's. divided by the armature resistance, with motor at rest, and the c.e.m.f. is of course zero, this difference is too great, and the temporary expedient is adopted of artificially increasing the armature resistance so that ruinous conditions will be avoided. In consequence of the few moments only during which this variable resistance, technically called a rheostat, is in circuit, it can be made of relatively small dimensions. Due to overloads and consequent blowing of fuses, or to opening of automatic switches, called "circuit-breakers," at the generating stations, interruptions of service are occasionally ex-

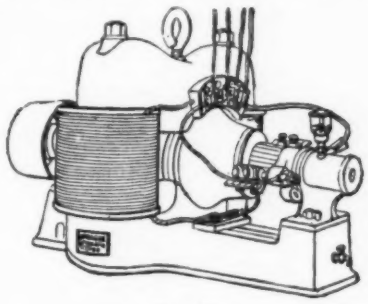


FIG. 32.

perienced. If a motor thereby stopped with its rheostat all cut out, there would at once be likelihood of some such accident as just mentioned, and a number of such circuits might make an unnecessarily large or dangerous draft on the generators. To forestall such a contingency, rheostats are now commonly supplied with "releases," that completely open the armature circuit whenever the current fails; that condition means dead wire or no voltage, and the designation of "no-voltage" release is one well known to electrical workers. A small electro-magnet is wound with fine wire and included in the shunt field magnet circuit; it is just strong enough to hold the rheostat arm in the "on" position, as shown in Fig. 33, against the opposite action of a spiral spring. In case of failure of the current, the little magnet is de-energized, and allows the arm to fly back, and reinsert the resistance, preparatory to a new start. The device is simple and sufficiently reliable to allow electric motors to be operated even in the absence of ordinary oversight, for instead of actual accident there would be merely a stoppage of machinery. A further valuable property of the device is to protect the armature from burning out, or flying to pieces, by an accidental breaking of a

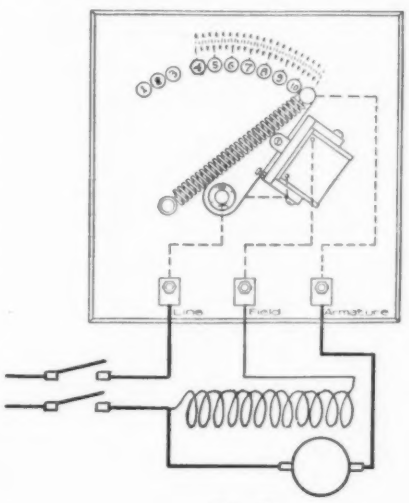


FIG. 33.

wire in the field magnet circuit, as such a fault would immediately operate the release and open the main circuit also.

A careful tracing of the circuits shown in Fig. 33 will give a comprehensive idea of the real function of the starting rheostat. The full-speed running condition is the one selected. Current can be assumed as entering at the wire marked "line," and reaching the post upon which the contact arm swivels; at this point the division of the current takes place, a small portion circulating around the release magnet, and then around the high resistance coils of the motor field magnet; the rest, and greater part, of the current traverses the arm and passes to the last contact, No. 11, then to one brush resting on the commutator, through the armature winding to the other brush, and unites with the field current in a common return to the other line wire. Imagining the main switch to be opened, for stopping the motor, the "release" will not instantly operate, for what was a counter electro-motive force has a chance to assert its existence, and as long as sufficient speed remains, the motor armature will supply a gradually diminishing current to the field circuit. When the arm does fly back the field circuit will not be broken and only a small flash will be produced at the first "live" contact No. 4. If now the main switch should be closed, or if the motor had been stopped by thrusting the rheostat arm to the "off" position, current would flow through the field coils, and in the absence of the fanning action of the armature, they would increase in temperature to an abnormally high degree. To avoid this contingency, the field circuit is often tapped off, not from the post, but from contact No. 4. Therefore, with the arm in the "off" position, both circuits will be dead. In starting, the main switch is first closed, and then the contact arm moved forward; upon reaching No. 4, the motor will start with full strength of field, but the further movement of the arm, while cutting out the resistance in the armature circuit will insert it in the field current. This is, however, negligible, as the field current is small, and the resistance of the rheostat negligible in comparison with that of the field itself. To tap off the field circuit at contact No. 11 would not be allowable, for while it would give good running conditions, it would result in a weak field at the start, for no greater potential would then be impressed upon the field than upon the armature. With field connected at No. 4 contact, there is a lively flash at the stopping of the motor, produced by the sudden rupture of the highly inductive field winding, and the use of the several dead contacts is the better to minimize this energetic exhibition of fireworks.

Series-wound motors, as stated, form a special class and their consideration will be given in Chapter IX., while Chapter X. will be devoted to their appropriate starting and controlling devices.

RAIL TESTING ON THE PENNSYLVANIA RAILROAD.

REPORTS which have recently appeared concerning certain tests the Pennsylvania Railroad has been making have created an entirely erroneous impression. It has been stated that the company was racing steam and electric locomotives, with a view to determining the speed capacity of each type. The experiments are not speed tests. Experience indicates that the operation of electric locomotives, owing to their lower center of gravity, has an effect upon the track entirely different from that due to the action of steam engines. It is in order to ascertain the exact nature and extent of this pressure upon the rails that the experiments have been made.

A stretch of track about 166 feet in length has been equipped with rails and cast steel ties, designed and made especially for this purpose. Instead of attaching the rail to the ties by spikes, a special form of block has been substituted which allows a slight movement of the rail as the engine goes over it; this movement registers the force with which the flanges of the wheels strike or press against the rails. It is expected that a large number of experiments with this apparatus will show the company quite accurately what the effect is of either steam or electric locomotives, moving at different speeds over either straight or curved track.

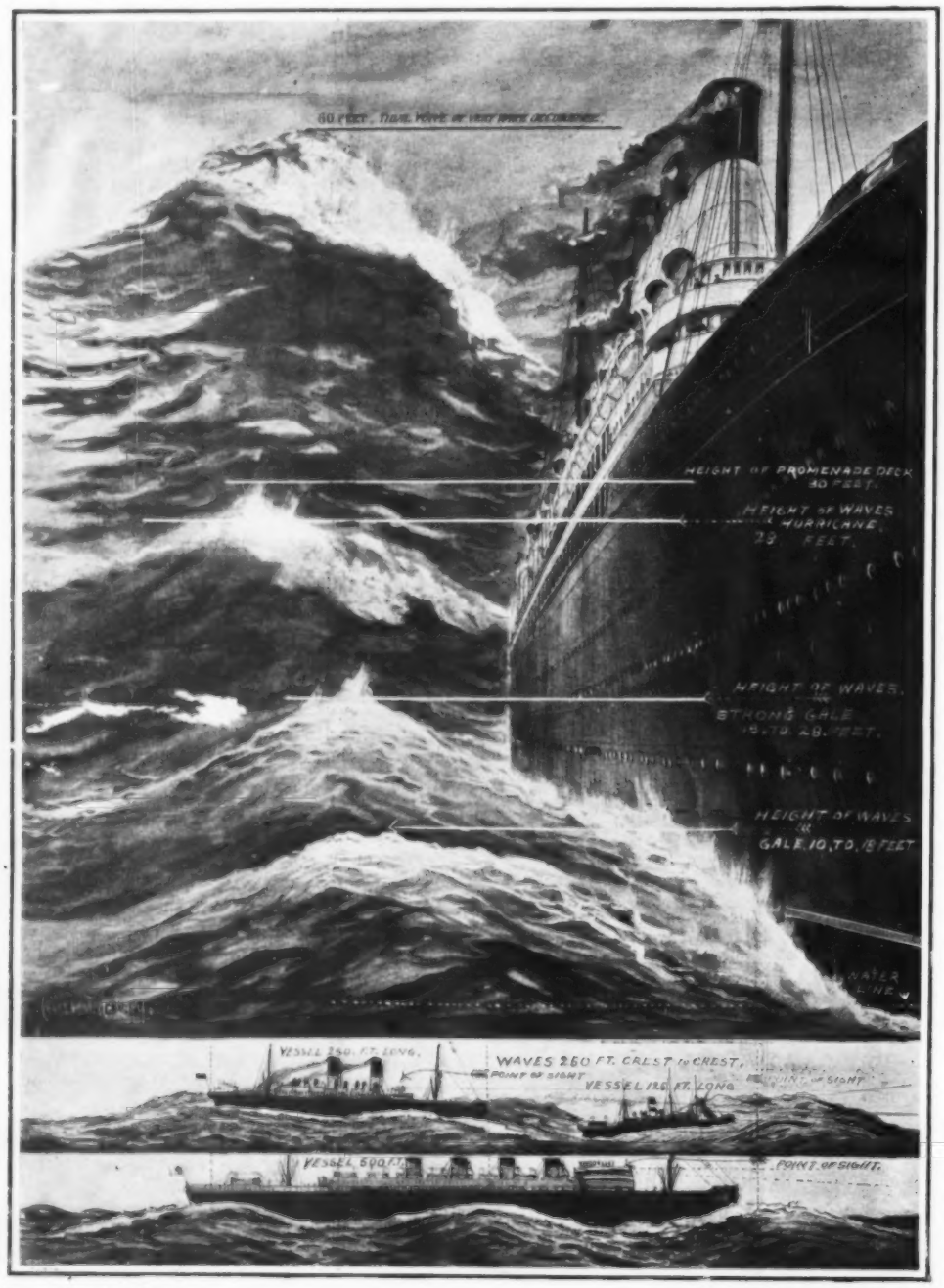
An electric apparatus has been devised to measure the precise amount of time elapsing while the different locomotives pass over this 166 feet of track, in order that in computing the effect upon the track, the exact speed attained may be known. The purpose of the tests is to enable the company to design a safe track in planning its electric installation in New York.

There are few persons who know how the name of "buckboard" came to be applied to a vehicle, says the American Vehicle. It was back in the '20's, when the transportation of goods, wares, and merchandise was almost entirely by wagon. A Dr. Buck, who for many years afterward was the military storekeeper at Washington, was then in charge of military stores *en route* to army posts in the Southwest. In East Tennessee much difficulty was experienced by reason of the rough roads, and there were frequent mishaps, mostly from the wagons overturning. Dr. Buck overhauled the outfit, and, abandoning the wagon bodies, long boards were set directly on the axles, or hung below; and the stores were loaded in such a manner that there were no further delays from breakdowns, and the stores safely reached their destinations. In special emergency, too, the load could be shifted or taken off in a hurry. The idea was probably not new, but Dr. Buck's example was followed, especially when roads were rough, and soon much hauling was done by the use of wheels, axles, and boards only. Now we have the buckboard, both in carriage and automobile forms, conforming closely to the original idea, though few suspect the source of it.

THE MASTERY OF THE OCEAN.

THE SIZE OF OCEAN WAVES.

THE first week of December, 1907, will long be remembered as one of the most boisterous in the annals of transatlantic travel. The steamers which made the western passage encountered what was almost a continuous gale, from the time they left the English Channel and the Irish coast until they passed the Sandy Hook lightship. Not only were the winds at times of cyclonic force, but the captains of the various ships agree in stating that the seas were among the heaviest of the elements, and whose power will never be so great but her speed will be to some extent cut down by the combined resistance of the wind and sea. But having admitted this much, it was proved in the recent rough passage that increase in size and power contributes enormously to the comfort of the passengers and the average speed of the trip. A length of close upon 800 feet, a beam of 88 feet, and a draft of 34 feet, to say nothing of a displacement of over 40,000


60 FEET. TIDAL WAVE OF VERY RARE OCCURRENCE.
HEIGHT OF PROMENADE DECK 40 FEET.
HEIGHT OF WAVES IN HURRICANE. 29 FEET.
HEIGHT OF WAVES. STRONG GALE 15 TO 20 FEET.
HEIGHT OF WAVES IN GALE 10 TO 15 FEET
WATER LINE
VESSEL 250 FT. LONG.
WAVES 250 FT. CREST TO CREST.
POINT OF SIGHT
VESSEL 150 FT. LONG.
POINT OF SIGHT
VESSEL 500 FT.
POINT OF SIGHT.

Drawn by Charles de Lacy. From the Illustrated London News.

THE RELATIVE HEIGHTS OF THE OCEAN WAVES COMPARED WITH THE "MAURETANIA" AND THE "LUSITANIA."

The phrase "waves mountains high" is an exaggeration, for science has shown that the biggest wave in a severe gale does not exceed thirty feet. Tidal waves are an exception, and these have been known to reach the height of sixty feet. With the increase in the size of ocean steamers, the point of sight of the passenger has been raised, and it requires a very rough sea indeed to show a broken horizon from the promenade deck of the "Mauretania" or the "Lusitania," which are perfectly steady in the roughest water. In the smaller steamers of former years, where the point of sight was low, the waves very often appeared mountainous. The diagrams at the foot of the picture illustrate how this illusion arose.

encountered in their experience. The fact that although all of the ships were some days late in arriving none of them received any serious damage, testifies to the high state of perfection which the art of constructing and navigating the modern ocean liner has reached. Of all the ships which made the passage, the greatest interest naturally attaches to the "Lusitania," which, because of her great size and power, would be expected to show superior ability, not only to smash her way at high speed through the heavy seas, but to do so with far less discomfort to the passengers than would be experienced on a smaller vessel. Let it be recorded then, at the outset, that her experience in the boisterous weather she encountered makes it certain that the ship will never be built whose size is such that she will not be more or less the sport of the elements, and whose power will never be so great but her speed will be to some extent cut down by the combined resistance of the wind and sea. But having admitted this much, it was proved in the recent rough passage that increase in size and power contributes enormously to the comfort of the passengers and the average speed of the trip. A length of close upon 800 feet, a beam of 88 feet, and a draft of 34 feet, to say nothing of a displacement of over 40,000 tons, provide dimensions and mass to which even the most furious of Atlantic gales are able to impart only slow and rhythmical movements of pitching and rolling. Although the rise and fall of the bow must at times have been as great as 50 feet, the movement, except on rare occasions, was gradual, and did not involve those sudden changes of position which are so strongly provocative of seasickness. So also the rolling, which rarely reached ten degrees each side of the normal, was very slow, and was accompanied by an appreciable period of rest before recovery. It has been proved in this ship beyond question, that increase of comfort is gained by increase of size, and the future is certain to see a growth in the dimensions of transatlantic ships, whose only limits will be those imposed by the length of piers at which the ships lie, and the depth of the harbor channels through which they must pass.

The 70,000 horse-power, quadruple turbine engines proved to be admirably adapted for driving the vessel into a heavy head sea. "Racing," that bugaboo of the marine engineer, has been practically eliminated. The four propellers are so deeply immersed, and their diameter is relatively so small, that the tips of the blades are fully 12 feet below the surface of the water; and, consequently, they are very rarely lifted clear of the water, even when the ship is pitching heavily. When they do lift, the speed of rotation is already so high, that the increase due to the lessened resistance is scarcely noticeable. Moreover, there is no lowering of the ship's speed, as in the case of a racing reciprocating engine; the thrust on the ship being constant, or subject to only slight variations. This even thrust, coupled with the fine entrance lines of the ship and her great momentum, enabled the "Lusitania" to maintain a remarkably even and high rate of speed against the biggest seas that were encountered. There was none of that severe impact, loss of speed, and subsequent acceleration which mark the performance of a ship driven by reciprocating engines. Consequently, the turbine as a drive for big ships has already rendered itself very popular with the officers on the navigating bridge. During the first heavy gale, which was encountered off the coast of Ireland, the ship was driven into enormous head seas for some hours at a speed of over 23 knots an hour. Ultimately, in spite of her freeboard forward of fully 50 feet, she began to ship green seas, which swept the fore deck, tore loose the derrick booms, and began to batter in the lighter plating of the forward breastworks. Subsequently, for the rest of the trip, she was driven under reduced power, the revolutions being about 157, as against the maximum speed of 180 per minute. This passage proved that if suitable alterations were made forward on the forecastle deck and the bridge structures, in the way of breakwaters and extra heavy scantling, and plating sufficient to stand the impact of the seas, it would be possible to drive a ship of this size with the full power of her engines through any gale which might be encountered and maintain a speed of 23 knots an hour against it. Such a ship, however, must be prepared to take on board and resist the impact of solid green seas, which may be at times 10 or 15 feet deep on the highest forward deck. The navigating bridge of this ship is 70 feet above the water, and yet at times the seas struck the rails and stanchions so heavily as to bend and split them in several places. Probably the best provision for heavy weather would be some form of turtleback deck forward, with the navigating bridge and pilot house carried upon a light framework above it, the forward end of the deck structures being given something of a snowplow shape, with a view to deflecting the seas that come on board, and throwing them clear of the passenger promenades and deck houses.

Preparation of Watch Oils.—A mixture is prepared of cocoanut oil, spermaceti, olive oil, neat's foot oil, and a very small quantity of mineral oil. The cocoanut oil and the spermaceti will remain liquid even at very high temperatures. The mixture is exposed to sunlight in an open bottle until all the colored and foreign substances are collected at the bottom, and then filtered through a mixture of bone and wood charcoal. It is claimed that this oil retains no glutinous property and will not oxidize the metal, and that it will not deteriorate at all. There are great numbers of brands of horological oils. Each producer of course considers his the best. Unfortunately, competition compels him to lower the price, which often results in the deterioration of the quality. Now, every oil designed for such delicate mechanism as that of watches should be free from acid or mucilage. In a word, it ought to be pure oleine. The method of securing oleine is not difficult. It consists in putting the oil into a receiver, with eight times its weight of concentrated alcohol, boiling for ten minutes, decanting the liquid, allowing to cool, evaporating until its volume is reduced to one-fifth, filtering, and keeping in a well-stopped bottle.

In deciding to build a viaduct of reinforced concrete, the Richmond and Chesapeake Bay Railway were influenced by several factors. By this choice a permanent structure was secured—timber was one of the alternative suggestions—and safety from fire. There are no metallic surfaces calling for paint; and it is easy to make, at a small expense, modifications of design to allow for the addition of another track later. Incidentally, concrete absorbs much of the noise of traffic, an advantage where railroads pass through cities.

A GIGANTIC PLANER.

THE BIGGEST MACHINE OF ITS KIND EVER MADE.

PROBABLY the largest and heaviest metal-working planer ever built has recently been shipped from the Bement-Niles Works (Philadelphia) of Niles-Bement-Pond Company. The total weight of the machine is 845,000 pounds, or 422½ tons. Four motors with a total capacity of 207½ horse-power are required to operate this remarkable tool.

The machine is, in general effect, an extremely large planer, but in addition to the movements found on a standard machine, many new ones have been added. Each head is fitted with a slotter bar independently driven by rack, giving a cutting speed that is practically constant from one end of the stroke to the other, and a quick return. Through motor and change gears the cutting and return speeds can be altered as desired. Each head is arranged for transverse planing, having a planing movement across the bed, which can be varied within desired limits and a quick return.

These movements for slotting and transverse planing make it necessary to throw out the regular driving mechanism to the table and connect it to a separate feed motion which, in this case, is entirely distinct from the regular feed motion. This throwing out of the driving mechanism, however, means simply that the pneumatic driving clutches are thrown into and left in their idle position.

The machine is fitted with its own air compressor and motor, thus making it independent of the air supply in the shop, to which, however, it can be connected if it seems desirable.

A complete switchboard is furnished for control of all the motors.

The distance between uprights is 14 feet 4 inches; the maximum distance from table to bottom of cross slide is 12 feet 2 inches; maximum stroke of table is 30 feet; maximum stroke of slotter bar is 5 feet; total width of bed is 13 feet; length of bed 60 feet; table ways 15 inches each in width; tool slides 7 feet 8 inches with 4 feet vertical traverse; cross rail is long enough to admit full traverse of either head between the posts; face of uprights 2 feet 6 inches; vertical height of cross slide, including the top rib bracing, is 5 feet.

The main driving motor is 100 horse-power; slotting and cross planing motor is 50 horse-power; lifting motor to cross slide 20 horse-power; traverse motor for heads on cross slide 7½ horse-power; air compressor motor 30 horse-power.

The cutting and return speeds are variable through the motor, which has a 1 to 1¼ variation and further range by change gears. The cutting speeds are 14 to 25 feet and return speeds 52½ to 65½ feet. The same style of drive is used for the slotter and gives a cutting speed of 18½ to 30 feet and return speed of 57 feet to 71 feet. Cutting speed for cross planing is 11½ to 19 feet and return speed 35 to 43½ feet. The cross traverse speed to the heads is 50 inches per minute; the vertical speed for raising and lowering cross slide is 26 inches per minute.

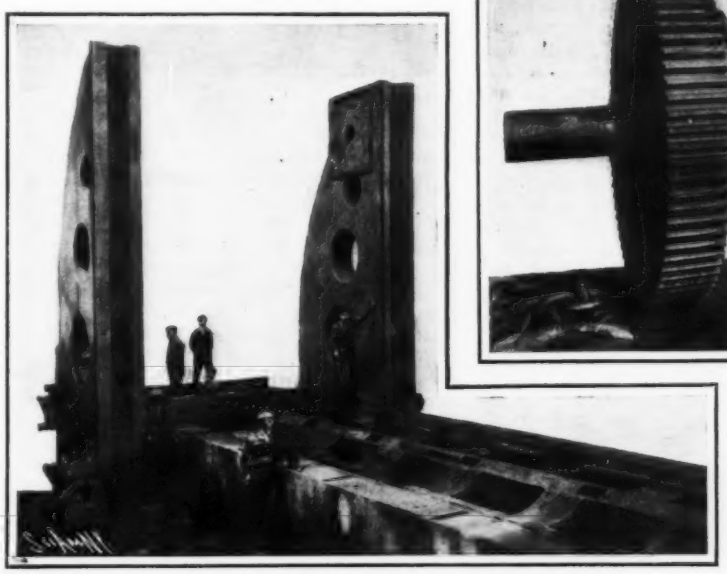


FIG. 3.—THE PLANER IN PROCESS OF ERECTION.

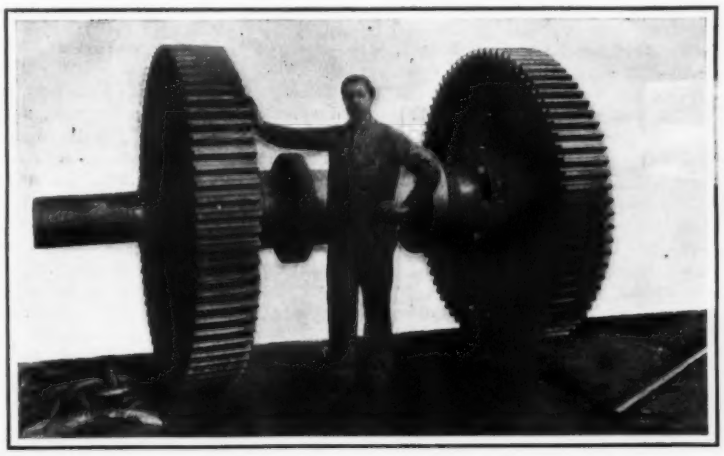


FIG. 4.—THE TWO LARGE BULL WHEELS.

The main drive from the 100-horse-power motor is clearly shown in Figs. 1 and 2, being through the gearing shown, to the pneumatic reversing clutches at the base of the upright. The speed of these clutches can be varied to some extent, as stated above, by changing the speed of the motor and a great variation obtained by the simple reversal of two change gears. The pneumatic clutches which are shown thoroughly incased are of the well-known N-D-P [illegible] with a large number of friction discs whereby great friction area is obtained in a comparatively small compass. These clutches, as their [illegible] are operated by compressed air. A small valve, easily moved by hand, controls the stopping, starting, and reversal of table, and handles satisfactorily the power given out by the large driving motor. In the handling of this amount of power in a motor-driven planer, it is unnecessary to state that it would be quite impracticable if a belt drive was employed. From this point, on to the rack, the drive is, in practically every respect, that which is found on any planer, except, of course, in this instance it is exceptionally heavy and powerful.

It might be noted, however, that the drive is all of steel and the two bull pinions are forged directly on the shaft, being cut half pitch apart in order to

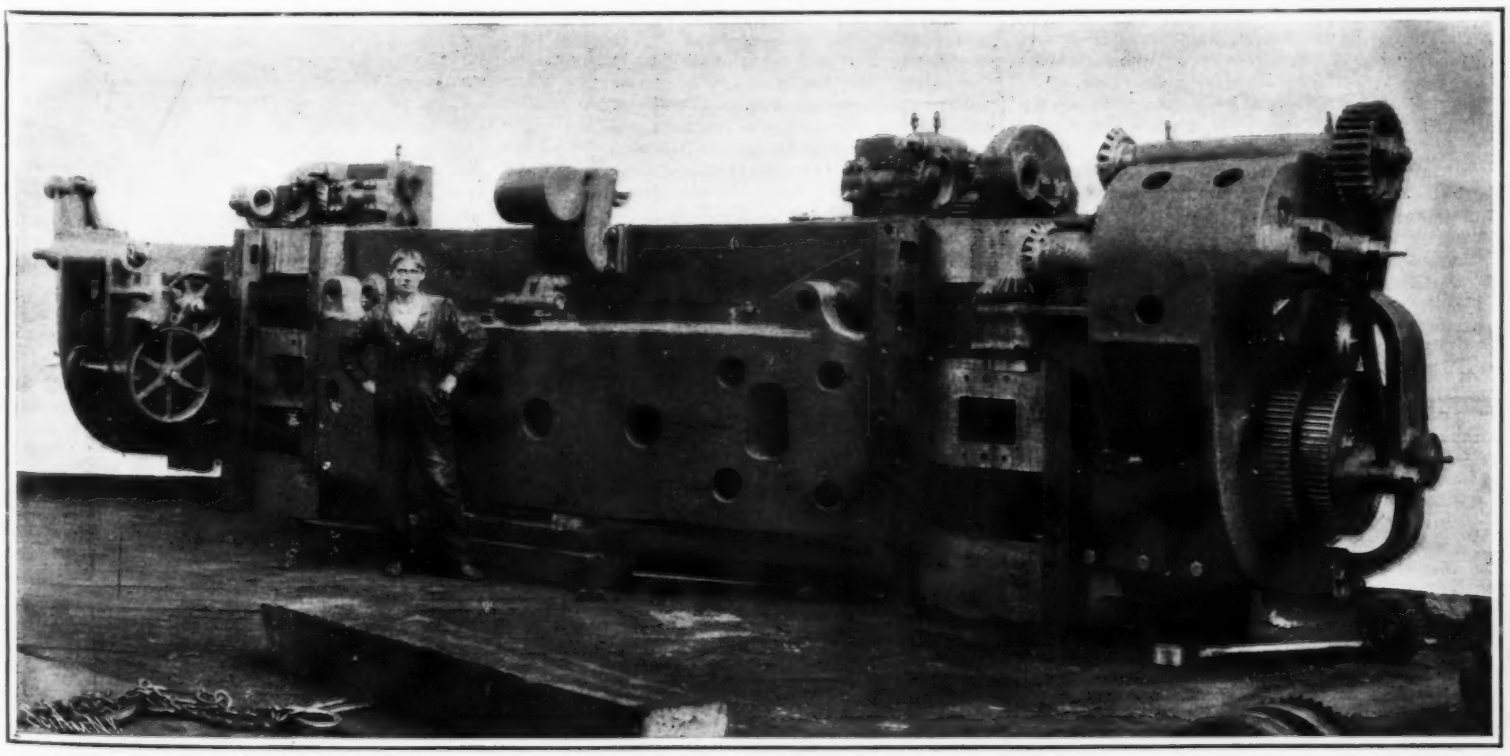


FIG. 7.—REAR VIEW OF THE CROSS RAIL.

give smoothness of motion, as referred to under Fig. 4.

Among the many other new features not the least is the pneumatic feed. The feed for the cross heads is very clearly shown in Fig. 2. On the side of the upright just above the gearing, is a cylinder with piston rod extending to the left. This rod carries a rack which meshes into a gear near the bottom of the vertical feed shaft. This shaft has on its lower end a bevel gear meshing into another bevel gear on a horizontal shaft which transmits motion to the vertical feed shaft on the left-hand upright. The movement of these feed shafts is constant at all times and variation in amount and direction of head feeds is obtained by adjusting the connecting rod in the slotted cranks on the ends of the cross-slide. These cranks are graduated in such a way that definite cross and vertical feeds can be obtained, and by using at the same time the cranks on both sides an angular feed can be given to the tool, which is at times desirable, as the whole heads were not designed to swivel. The valve for controlling the air to the feed cylinder is thrown automatically at each end of the stroke, this movement being taken from either the main driving gear-train to the table or the slotter gearing, when slotting is being done. To throw out the feed, it is simply necessary to close a valve, cutting off the air supply.

In Fig. 2 the feed for the table, when slotting or transverse planing is being done, has not yet been placed in position, but it is shown in Fig. 1, directly in front of and at the base of the upright. This feed operates practically the same as the feed for the cross head previously described, except that variation in stroke or amount of feed is obtained by an adjustable stop which regulates the amount of movement of the piston in the cylinder. This adjustment is made by the right-hand hand-wheel; the left-hand hand-wheel is for connecting and disconnecting this feed mechanism to the main driving works.

Fig. 6 shows the slotter drive, although Fig. 5 gives it in more detail.

The description of the main drive on the opposite upright fits this one up to and including the pneumatic clutches. For the main drive the power is then carried through the upright into the bed, while for the slotter drive it is, as shown, transmitted to the vertical square shaft and thence by bevels and spur gearing to the horizontal square shaft running along the top of the cross slide. The pinion on this shaft drives the large gear, of which, however, only the cover can be seen, and the rack pinion which gears into the back of the cutter bar is on the same shaft with this gear. The pinion on the square shaft slides and can be thrown in or out of gear as desired, so that either or both bars can be used. The disk shown just above the motor controls the length of stroke. This disk is driven from the main train of slotter gearing and the adjustable stops on its periphery can be set at any desired point and effect the reversal in the same way as do dogs on the side of a planer table. Near the bottom of the square vertical shaft in Fig. 5 may be seen the bevel gear on the end of a horizontal shaft which goes across the bed and which can be connected to the mechanism operating the valve of the feed cylinder on the opposite side, as mentioned in the description of the feed for the heads.

On Figs. 1, 2, and 6 can be seen a vertical shaft where the reversing hand lever of a standard planer is usually found. It will be noticed that there are two sockets at the upper end, in one of which is a handle. The upper socket is connected to a shaft which runs down to the bottom lever or crank. This is the hand control of the slotter. The method of connection can be followed quite clearly, starting as shown in Fig. 1, going through the bed and coming out on the opposite side, as shown in Fig. 6, and then by the curved connecting rod running in back of the upright and out through the upright to the slotter reversing mechanism at the reversing disk.

The lower socket is the one that controls the movement of the table when regular planing is being done and is connected by lever and rods to the reversing dogs on the bed on both sides. Only one handle is furnished for each side and thus mistakes arising from throwing the wrong lever are avoided.

Owing to the great weight and large dimensions it was impracticable, both from a manufacturing and a shipping standpoint, to make the bed or table in one piece. They were therefore divided to bring them within reasonable limits. The central section of the bed is divided longitudinally into three parts, and the two end sections into two parts, or seven parts in all. The total weight of the bed is about 275,000 pounds. The table is made in two sections divided longitudinally in the center and weighs 140,000 pounds.

The holes in the table for stop bolts, etc., run entirely through the upper plate, while below this is a second plate without openings extending the full width of table for catching all chips. The chips can then be removed through the side openings of the table, which are clearly shown in Figs. 1 and 6.

The motor for fast traverse of heads is shown on the end of the cross slide in Fig. 2. The reversing is done through friction clutches and a safety is provided which prevents throwing in the fast traverse and the feed mechanism at the same time.

The motor for operating the rail is situated at the top of the upright, as shown in Figs. 1 and 2. This motor is connected at all times to the elevating screws and is stopped, started, and reversed electrically.

On the end of the table, in Figs. 1 and 6, are shown finished pads over the V and flat ways. These are to carry the heads for truing up the ways when worn out of alinement. The method is as follows:

The table is raised say ¼ inch above the ways and supported in this position on sliding blocks fitting the inner small auxiliary shears, which are used only for this purpose. The truing heads being fastened to the end of the table, the ways are trued up from the center to the end. The heads are then placed on the opposite end of the table and the remainder of the ways finished. Near the center of the bed are pockets in the ways in which these same truing heads are placed and the table is in its turn then planed up in the same manner. The accuracy, of course, of the finished work is dependent entirely upon the accuracy of the small auxiliary ways, and these are, therefore, finished and erected with great care.

The elevating screws for cross slide are firmly held top and bottom and the nut in the cross slide acts into a shouldered end in a square pocket. It is expected that this will take care of the slotter bar thrust satisfactorily, but if any loosening or trouble is experienced, arrangements have been made so that the slide can be firmly braced to the uprights.

THE PROBLEM OF THE METALLIFEROUS VEINS.*

A GEOLOGICAL QUESTION.

BY JAMES FURMAN KEMP.

Concluded from Supplement No. 1669, page 403.

THE compounds of copper, lead, zinc, silver, nickel, cobalt, quick-silver, antimony, and arsenic with sulphur present more difficult problems and ones into whose chemistry it is impossible to enter here in any thorough way, but in general it may be said that the solutions were probably hot, that they were in some cases alkaline, in others acid, and that the pressure under which they took up the metals in the depths has been an important factor in the process. The loss of heat and pressure as they rose toward the surface no doubt aided in an important way in the result.

The first condition for the production of an ore deposit is a waterway. It may be a small crack, or a large fracture, or a porous stratum, but in some such form it must exist. Naturally porous rock affords the simplest case and provides an easily understood place of precipitation.

We may raise the question as to the source of the water which accomplishes these results, and the further question as to the cause of its circulations.

The nature of the underground waters, which are instrumental in filling the veins, presents one of the most interesting, if not the most interesting, phase of the problem, and one upon which attention has been especially concentrated in later years. The crucial point of the discussion relates to the relative importance of the two kinds of ground waters—the magmatic, or those from the molten igneous rocks, and the meteoric, or those derived from the rains. The magmatic waters are not phenomena of the daily life and observation of the great majority of civilized peoples, and for this reason they have not received the attention that otherwise would have fallen to their share. Relatively few geologists have the opportunity to view volcanoes in active eruption, and have but disproportionate conceptions of the clouds and clouds of watery vapor which they emit. It is on the whole not surprising that to the meteoric waters most observers in the past have turned for the chief, if not the only, agent. I will therefore first present, as fully as the time admits and as fairly as I may, this older view, which has perhaps the larger number of adherents.

* From a presidential address before the New York Academy of Sciences.

Except in the arid districts, rain falls more or less copiously upon the surface of the earth. The largest portion of it runs off in the rivers; the smallest portion evaporates while on the surface, and the intermediate part sinks into the ground, urged on by gravity, and joins the ground waters. Where crevices of considerable cross section exist, they conduct the water below in relatively large quantity. Shattered or porous rock will do the same, and we know that open-textured sandstones, dipping down from their outcrops and flattening in depth, lead water to artesian reservoirs in vast quantity. As passages and crevices grow smaller the friction on the walls increases and the water moves with greater and greater difficulty. When the passage grows very small, movement practically ceases. The flow of water through pipes is a very old matter of investigation, and all engineers who deal with problems of water supply for cities or with the circulation of water for any of its countless applications in daily life must be familiar with its laws. Friction is such an important factor that only by the larger natural crevices can the meteoric waters move downward in any important quantity or with appreciable velocity. They do sink, of course, and come to comparative rest at greater or less distance from the surface and yield the supplies of underground water upon which we draw.

The section of the rocks which stands between the surface and the ground water is the arena of active change and is that part of the earth's crust in which the meteoric waters exercise their greatest effect. Rocks within this zone are in constant process of decay and disintegration. Oxidation, involving the production of sulphuric acid from the natural metallic sulphides, is actively in progress. Carbonic acid enters also with the meteoric waters. The rocks are open in texture and favorably situated for maximum change. From this zone we can well imagine that all the finely divided metallic particles, which are widely and sparsely distributed in the rocks, go into solution and tend to migrate downward into the quiet and relatively motionless ground water. If the acid solutions escape the precipitating action of some alkaline reagent, such as limestone, they may even reach the ground waters, and their dissolved burdens may be contributed to this reservoir, but the greater portion seems to be deposited at the level of the ground water itself or at moderate distances below it. Impressed by these phenomena, which present a true cause of solution, and influenced by their familiar and everyday character, we may build up on the basis of them a general conception of the source of the metallic minerals dissolved in those aqueous solutions which are recognized by all to be the agents for the filling of the veins.

Let us now focus attention on the ground water. This saturates the rocks, fills the crevices, and forces the miner who sinks his shaft to pump, much against his natural inclination. The vast majority of mines are of no great depth, and the natural conclusion of our earlier observers, based on this experience, has been that the ground waters extend downward, saturating the strata of the earth to the limit of possible cavities, distances which vary from 1,000 to more than 30,000 feet. To this must be added another familiar phenomenon. The interior temperature of the earth increases at a fairly definite ratio of about 1 deg. F. for each 60 to 100 feet of descent. In round numbers, if we start with a place of the climatic conditions of New York—that is, with a mean annual temperature of about 51 deg.—we should on descending 10,000 feet below the surface find a temperature of about 212 deg., and if we go still deeper, it would be still greater. Of course, under the burden of the overlying column of water, the actual boiling points for the several depths would be greater, and it is a question whether the increase of temperature would overcome the increase of pressure and the consequent rise of the boiling point so as to convert this water into steam, cause great increase in its elasticity, decrease in its specific gravity, and thereby promote circulations. At all events, the rise in temperature would cause expansion of the liquid, would disturb equilibrium, and to this degree would promote circulations.

There is one other possible motive power. The meteoric waters enter the rocky strata of the globe at elevated points, sink downward, meet the ground

water at altitudes above the neighboring valleys, and establish thereby what we call "head." In consequence, they often yield springs. If we imagine the head to be effective to considerable depths we have again the deep-seated waters under pressure, which after their long and devious journey through the rocks may cause them to rise elsewhere as springs. The head may in small degree be aided by the expansion of the uprising heated column, whose specific gravity is thereby lowered as compared with the descending colder column.

May we now draw all these facts and supposed or assumed phenomena into one whole?

The descending meteoric waters become charged with dissolved earthy and metallic minerals in their downward, their deep-seated lateral, and perhaps also at the beginning of their heated uprising journey. They are urged on by the head of the longer and colder descending column and by the interior heat. They gather together from many smaller channels into larger issuing trunk channels. They rise from regions of heat and pressure which favor solution, into colder regions of precipitation and crystallization. They deposit in these upper zones their burden of dissolved metallic and earthy minerals and yield thus the veins from which the miner draws his ore.

This conception is based on phenomena of which the greater part are the results of everyday experience. It is attractive, reasonable, and is on the whole the one which has been most trusted in the past. Doubtless it has the widest circle of adherents to-day. It is, however, open to certain grave objections, which are gaining slow but certain support.

The conception of the extent of the ground water in depth, for example, is flatly opposed to our experience in those hitherto few but yearly increasing deep mines which go below 1,500 or 2,000 feet. Wherever deep shafts are located in regions other than those of expiring but not dead volcanic action, they have passed through the ground water, and if this is carefully impounded in the upper levels of the mines and not allowed to follow the workings downward, it is found that there is not only less and less water, but that the deep levels are often dry and dusty. Along this line of investigation, Mr. John W. Finch, recently the State geologist of Colorado, has reached the conclusion, after wide experience with deep mines, that the ground waters are limited, in the usual experience, to about 1,000 feet from the surface and that only the upper layer of this is in motion and available for springs.

Artesian wells do extend in many cases to depths much greater than this and bring supplies of water to the surface, but their very existence implies waters impounded and in a state of rest.

To this objection that the ground waters are shallow it has been replied that when the veins were being formed the rocks were open-textured and admitted of circulation, but subsequently the cavities and waterways became plugged by the deposition of minerals by a process technically called cementation, and the supply being cut off, they now appear dry. There must, however, in order to make the "head" effective, have once been a continuous column of water which introduced the materials for cementation. It is at least difficult to understand how a process which could only progress by the introduction of material in very dilute solution should, by the agency of crystallization, drive out the only means of its production. Some residue of water must necessarily remain locked up in the partially cemented rock. This residue we of course do not find where rocks are dry and drifts are dusty. In many cases also, where deep cross cuts have penetrated the fresh wall rock of mines, cementation, if present, has been so slight as to escape detection.

If we once admit that this conclusion is well based, it removes the very foundation from beneath the conception of the meteoric waters and tumbles the whole structure in a heap of ruins.

While I would not wish to positively make so sweeping a statement as this about a question involving so many uncertainties, there is nevertheless a growing conviction among a not inconsiderable group of geologists that the rocky crust of the earth is much tighter and less open to the passage of descending waters than has been generally believed and that the phenomena of springs which have so much influenced conclusions in the past affect only a comparatively shallow, overlying section. Such phenomena of cementation as we see are probably in large part due to the action of water stored up by the sediments when originally deposited and carried down by them with burial. Under pressure, a relatively small amount of water may be an important vehicle for recrystallization.

It has been assumed in the above presentation of the case of the meteoric waters that they are able to leach out of the deep-seated wall rocks the finely disseminated particles of the metallic minerals, but the conviction has been growing in my own mind that we have been inclined to overrate the probability of this action in our discussions. In the first place, our knowledge of the presence of the metals in the rocks themselves is based upon the assay of samples almost always gathered from exposures in mining districts. The rock has been sought in as fresh and unaltered a condition as possible and endeavors have been made to guard against the possible introduction of the metallic contents by those same waters which have filled the neighboring veins. But if we admit or assume that the assay values are original in the rock, and, in case the latter is igneous, if we believe that the metallic minerals have crystallized out with the other bases from the molten magma, we are yet confronted with the fact that their very presence and detection in the rock show that they have escaped leaching, even though they occur in a district where underground circulations have been especially active. From the results which we have in hand it is quite as justifiable to argue that the metals in the rocks are proof against the leaching action of underground circulations as that they fall victims to it. These considerations tend to restrict the activities of the meteoric waters to the vadose region, as Posepny calls it, i.e., that belt of the rocks which stands between the permanent water level and the surface. Within it is an active area of solution, as we have all recognized for many years, but, as previously stated, experience shows that the metals which go into solution in it strongly tend to precipitate at or not far below the water level itself.

Let us now turn to the magmatic waters. That the floods of lava which reach the surface are heavily charged with them there is no doubt. So heavily charged are they that Prof. Edouard Suess, of Vienna, and Prof. Robert T. Hill, of New York, have seen reason for the conclusion that even the oceanic waters have in the earlier stage of the earth's history been derived from volcanoes rather than, in accordance with the old belief, volcanoes derive their steam from downward percolating sea water. From vents like Mont Pelé, which in periods of explosive outbreaks yield no molten lava, the vapors rise in such volume that cubic miles become our standards of measurement.

There is no reason to believe that many of the igneous rocks which do not reach the surface are any less rich, and when they rise so near to the upper world that their emissions may attain the surface we must assign to the resulting waters a very important part in the underground economy.

This general question has attracted more attention in Europe in recent years as regards hot springs than in America. So many health resorts and watering places are located upon them that they are very important foundations of local institutions and profitable enterprises. Prof. Suess has stated that Rosiwal, who had studied the Carlsbad district, could not detect any agreement between the run of the rainfall and the outflow of the springs, and that both the unvarying composition and amount through wet seasons and dry were opposed to a meteoric source. Water, therefore, from subterranean igneous rocks, well known to exist in the locality, was believed to be the source of the springs. The same general line of investigation has led other observers to similar conclusions for additional springs, so that magmatic waters have assumed a prominence in this respect which leaves little doubt as to their actual development and importance.

All familiar with western and southwestern mining regions know as a matter of experience that the metalliferous veins are almost always associated with intrusive rocks, and that in very many cases the period of ore formation can be shown to have followed hard upon the entrance of the eruptive. The conclusion has therefore been natural and inevitable that the magmatic waters have been, if not the sole vehicle of introduction, yet the preponderating one.

With regard to their emission from the cooling and crystallizing mass of molten material we are not perhaps entirely clear or well established in our thought. So long as the mass is at high temperatures the water is potentially present as dissociated hydrogen and oxygen. We are not well informed as to just what is the chemical behavior of these gases with regard to the elements of the metallic minerals. Hydrochloric acid gas is certainly a widely distributed associate. If, as seems probable, these gases can serve, alone or with other elements, as vehicles for the removal of the constituents of the ores and the gangue, the possibilities of ubiquitous egress are best while the igneous rock is entirely or largely molten. In part even the phenomena of crystallization of the rock-forming minerals themselves may be occasioned by the loss of the dissolved gases. Through molten and still fluid rock the gases might bubble outward if the pressure were insufficient to restrain them and would, were their chemical powers sufficient, have opportunity to take up even sparsely distributed metals.

On the other hand, if their emission, as seems more probable, is in largest part a function of the stage of solidification and takes place gradually while the mass is congealing or soon thereafter, then they must depart along crevices and openings. They might have and probably do have an enhanced ability to dissolve out in a searching and thorough manner the finely distributed metallic particles as compared with relatively cold meteoric waters which might later permeate the rock, but as regards the problem of leaching, the general relations of crevices to mass are much the same for both, and it holds also true that the discovery of the metals by assay of igneous rocks proves that all the original contents have not been taken by either process.

We may, however, consider an igneous mass of rock as the source of the water even if not of the ores and gangue, and then we have a well-established reservoir for this solvent in a highly heated condition and at the necessary depths within the earth. Both from its parent mass and from the overlying rocks traversed by it, it may take the metals and gangue.

In the upward and especially in the closing journey, meteoric waters may mingle with the magmatic, and as temperatures and pressures fall the precipitation of dissolved burdens takes [illegible] and ore bodies are believed to result. Gradually the source of water and its store of energy become exhausted; circulations die out and the period of vein formation, comparatively brief, geologically speaking, closes. Secondary enrichment through the agency of the meteoric waters alone remains to influence the character of the deposit of ore. In brief, and so far as the process of formation of our veins in the western mining districts is concerned, this is the conception which has been gaining adherents year by year, and which, on the whole, most fully accords with our observed geologic relations. It accords with them, I may add, in several other important particulars upon which I have not time to dwell.

In closing, I may state that speculative and uncertain as our solution of the problem of the metalliferous veins may seem, it yet is involved in a most important way with the practical opening of the veins and with our anticipations for the future production of the metals. Every intelligent manager, superintendent, or engineer must plan the development work of his mine with some conception of the way in which his ore body originated, and even if he alternates or lets his mind play lightly from waters meteoric to waters magmatic, over this problem he must ponder. On its scientific side and to an active and reflective mind it is no drawback that the problem is yet in some respects elusive and that its solution is not yet a matter of mathematical demonstration. In science the solved problems lose their interest; it is the undecided ones that attract and call for all the resources which the investigator can bring to bear upon them. Among those problems which are of great practical importance, which enter in a far-reaching way into our national life and which irresistibly rivet the attention of the observer, there is none with which the problem of the metalliferous vein suffers by comparison.

THE KING'S DRUGGIST.

KINGS, like other mortals, are subject to numerous ills, and frequently require the aid of the physician—far more frequently than is recorded, in fact. While an innumerable number of men and women have been murdered by tampering with the medicines they were taking, such a case is unknown among royalty of our days.

Recently one of our representatives had the good fortune to meet a gentleman who has dispensed medicines for practically every member of the British royal family, and this gentleman was good enough to throw some light on the subject.

In preparing physic for royalty, naturally all precautions are taken that the drugs are of the greatest purity. This does not suffice, however, for it might be possible for some evil person to obtain a position by hook or crook in the establishment where the royal medicines are dispensed.

Accordingly elaborate precautions are taken which render it a matter of impossibility for any mistake, either accidental or premeditated, to occur. Even if an anarchist were employed in the dispensary, all his attempts to do harm would be quite futile.

A special royal messenger takes the prescription to the royal dispensary, and there the exact time and date it is handed in is recorded, and the person who receives the envelope initials the record. Then the prescription is passed into a room used for no other purpose than dispensing these medicines. The greatest precautions are taken in keeping not merely the room, but every cupboard containing the various drugs, properly locked.

Inside the dispensary are a number of prescription books, each member of the royal family having a special book. The books are safeguarded in every way, even so far as being protected with massive fittings and special locks; needless to say, the books are always locked, except at the time when an entry is made.

The keys of these locks are again fastened in a special stronghold, which is sealed with special devices in such a way that it would be impossible to tamper with them without some trace being left.

The actual dispensing is done by two chemists, who

thus form a check on each other. As soon as the prescription reaches these men, the prescription book is unlocked, and the senior dispenser enters a copy of the prescription, the entry being checked by his junior.

Next, the particular cupboards are unlocked, and the requisite ingredients are withdrawn, every precaution being taken. Not only are the drugs, weights, and quantities checked by the two men, but the water itself is subjected to various delicate tests. It is scarcely necessary to add that after every safeguard has been taken, the drugs themselves are carefully analyzed.

The medicines are checked by every delicate process imaginable, and then carefully packed and placed in a special case, which is then carefully locked. The lock provided is exceptionally secure and complicated, and possesses two keys, one of which is kept at the dispensary, while in the case of the king the other is in the possession of his majesty. Thus it is impossible for the medicines to be tampered with after they have left the laboratory.

During the whole of these complicated processes, the two dispensers never lose sight of their charge, and they check each other in every imaginable way. The locked case is then handed over to a confidential person, who then conveys it to the royal personage for whom it is intended. The dispensers then carefully lock up and seal the articles and utensils which have been used.

The medicines at last go through further severe checking by the royal physician, which completes the elaborate processes. By these devices it is quite impossible for the royal medicines to be tampered with in any way.—Answers.

THE GAME OF DIABOLO.

HOW IT WAS PLAYED FOUR HUNDRED YEARS AGO.

BY HENRI D'ALLEMAGNE.

FASHIONS and "fads" come and go, and sometimes, as in the case of the game of diabolo, they return to favor after they have passed into oblivion. The French are especially addicted to fads, which extend their sway over almost the entire population. In the sixteenth century the game of bilboquet, or cup and ball, came into vogue at court and soon became universally popular. Henri III. played the childish game in the street and his courtiers and young men of all ranks soon followed the royal example. In the eighteenth century ladies of fashion carried little jointed wooden puppets, the limbs of which were moved by pulling cords.

At the commencement of the nineteenth century, the fashionable toy was the *emigrette*. It was composed of two disks of wood or ivory and was thrown so as to return to the hand. The name was given in satirical allusion to the *émigrés* who had fled during the revolution and were now returning, one by one, to their native land.

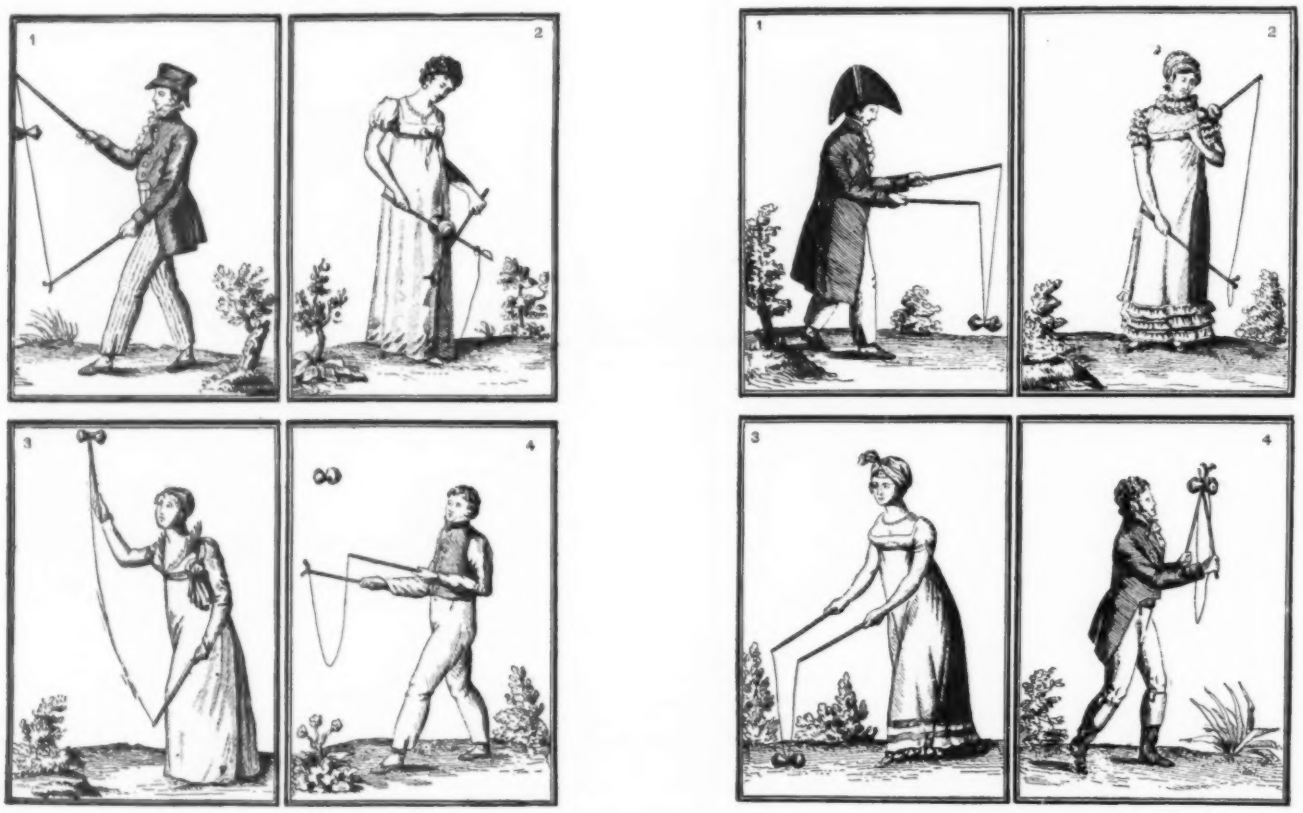
The game of diabolo made its appearance in 1812. It soon became a passion, not only with children, but with grave gentlemen and elegant ladies, who vied with one another in exhibiting their address, or lack thereof, to the great danger of costly mirrors and more or less valuable heads.

The diabolo is shaped like an hour glass, of two cones attached by their points, and the game consists in making it perform various evolutions with the aid of two short sticks connected by a cord. The first exercise is called the promenade and consists in causing the diabolo to run down one of the sticks and along the cord. If it is arrested and held motionless at the middle point of the cord, the result is called *vas comme je te pousse*, that is "obedience." Even these elementary exercises require much practice in balancing the elusive diabolo on the rod and cord.

In the "return," or *Jean s'en va comme il est venu*, the diabolo is returned to the rod from the cord by suddenly extending the latter and crossing the rods. In the "rack" (*chevalet*) the diabolo is caught and held between the ends of the crossed rods. It can also, by a skillful player, be balanced on the end of one rod, a feat which is called *grand équilibre du croissant*, and even caused to roll up the taut and sharply inclined cord (*ascension à la corde tendue*).

Still more difficult is the *saut périlleux*, or "leap for life," in which the diabolo is tossed high in the air and caught on the cord as it descends. Usually the diabolo, cord, and rods are of small dimensions, but in the variety of the pastime known as the *grand voltige* ("the slack rope") a large diabolo and a cord as thick as a bell rope are employed. An anonymous writer of the early part of the nineteenth century mentions a diabolo rope in the Champs Elysées which was 60 *toises*, or fathoms, in length, and was supported in the middle by a pole 20 feet high. "To add to the interest of the game," says the same writer, "two devils are sent up the two parts of the cord at the same moment. At the top they meet and dispute the path, and either both fall back or the heavier and swifter pursues its way, driving the other down before it."

The diabolo itself appears to have been introduced into France by a missionary who had found it used as a rattle in China. Chinese peddlers announce their approach by sounding huge rattles of this form. The game was an inspiration to the caricaturist a century ago, as it is to-day, but it is an excellent exercise for young people, as it requires not only skill, patience and perseverance, but a promptness of decision that is very desirable to inculcate. Unfortunately, the fickleness of popular taste in France will probably soon relegate it to oblivion, whence it may be rescued by some future antiquarian and made known to the world for the third time.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.



THE GAME OF DIABOLO AS PLAYED IN THE NINETEENTH CENTURY. FROM AN OLD PRINT.

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES IN 1906.

THE production of gold in the United States during 1906 was $94,373,800 as against $88,180,700 for 1905, a gain in 1906 of $6,193,100. The principal gain was in Alaska, which amounted to $6,439,5[illegible]. Nevada's gain in gold was $3,919,500, Oregon's $75,000, Arizona's $55,800. The total production of silver in the United States during 1906 is given as 56,517,900 fine ounces, of the commercial value of $38,256,400, as against 56,101,600 fine ounces, of the commercial value of $34,221,976 in 1905. The net gain in the production of silver over that of 1905 was 416,300 ounces. The average price of silver for the calendar year 1905 was $0.61027 per ounce, as against $0.67531 for the calendar year 1906.

It is stated that C. Bellia has examined the gases emitted by a fumarole on Etna, and by the salt-spring at Paternò, and from the dispersion produced by the gases when introduced into an Elster and Geitel electroscope, concludes that in each case the gas contains an emanation of the same nature as that of radium, the quantities contained by 1 liter of each being as much as is developed by 1 milligramme of pure radium bromide in 1/125 and 1/12 of a second respectively. Hence it is suggested that the radio-activity of volcanic products is the greater the less the depth from which it is projected. The gases have only been examined some time after collection, but so far no evidence of emanations of a thorium or actinium type has been detected.

THE ORIGIN OF BACTERIA FROM ALGÆ.

THE REMARKABLE THEORY OF PROF. DUNBAR.

BY DR. C. LAUENSTEIN.

PROF. DUNBAR, the director of the Hygienic Institute of Hamburg, recently published an account of experiments which appear to prove that bacteria and yeast and mold fungi are produced by algæ. So revolutionary and startling a theory advanced by a biologist of Dunbar's reputation has naturally aroused lively interest, and deserves careful examination and analysis.

After the theory of the spontaneous generation of bacteria had been exploded by the researches of Pasteur, Cohn, and Tyndall, it was generally assumed that bacteria had existed since the beginning of life as "constant species," susceptible of only slight modifica-

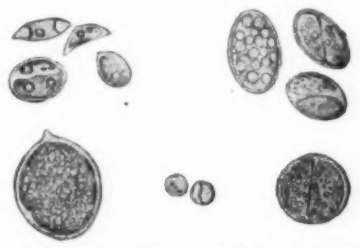


FIG. 1.—VARIOUS FORMS OF UNICELLULAR ALGÆ.

tions in their properties caused by differences in environment. Pathogenic bacteria, for example, may be more or less virulent. The possibility of bacteria generating forms unlike themselves (pleomorphism) was denied as positively as the possibility of individuals assuming various distinct forms under the influence of environment (polymorphism). Both of these peculiarities had been conceded to the mold fungi, but in this case it was impossible to obtain absolutely pure cultures of individual forms. Until recently every attempt to trace the origin of bacteria to pre-existent organisms proved abortive. No connection could be traced between bacteria, molds, and yeasts on the

FIG. 2.—STELLATE GROUPS OF BACILLI, OBSERVED IN CELLS OF ALGÆ.

one hand and higher cryptogams on the other. On the contrary, an impassable gulf appeared to separate plants destitute of chlorophyl from all other plants. Nor had pure cultures of algæ been subjected to thorough bacteriological examination.

Prof. Dunbar, who since the cholera epidemic of 1892 had been continuously engaged in the study of the water furnished by the watersheds of the Elbe, Oder, and Weichsel rivers, obtained in 1896 a pure culture of an alga of the family Palmellaceæ (Fig. 1). Algæ differ from bacteria, yeasts, and molds in many respects, but most conspicuously by containing chlorophyl, which occurs in none of the lower organisms. This pure culture of algæ formed the starting point

FIG. 3.—SPIRAL BACTERIA IN ALGÆ

of his researches, which have just been published.

In the course of his examinations of potable waters Dunbar came to the conclusion that bacteria are essentially connected with the life process of chlorophyl-bearing alga cells. He found forms resembling cholera germs and peculiar star-shaped clusters of bacilli (Fig. 2) in the interior of alga cells and he became convinced the bacteria had originated where they were found. Portions of the pure culture of algæ were added to distilled water and to sterilized river water. After a time bacteria were found associated with the algæ in the river water, but not in the distilled water. The experiments were so carefully conducted that the introduction of bacteria by organic contamination seem-

FIG. 4.—COCCI IN ALGÆ.

ed impossible, hence Dunbar concluded that the bacteria were produced by the algæ under the stimulus of the mineral salts contained in the river water. He tested this theory by many ingenious experiments, all of which were conducted with the original pure culture of algæ made in 1896.

Now, after years of preliminary researches, Dunbar has succeeded in observing the development of yeasts and molds, as well as bacteria, from his pure culture of algæ. He has published full details of his

FIG. 5.—SARCINE BACTERIA IN ALGÆ.

method of experiment and confidently awaits confirmation of his astonishing results by other observers.

As bacteria, yeasts, and molds are present everywhere, and especially in the environment of human beings, the utmost care is required in order to eliminate possible sources of error in these experiments. Every person who is familiar with the work of a bacteriological laboratory knows that trustworthy results cannot be obtained without scrupulous cleanliness, in the sense of absence of germs. It is not sufficient to

FIG. 6.—BACILLI IN ALGÆ.

make sure that all materials, vessels, and implements are absolutely free from germs, but infection from the air must also be prevented. The vessels, pipettes, culture liquids, etc., used in Dunbar's experiments were subjected for an hour to the action of steam at a pressure of 1½ atmospheres and a temperature of 128 deg. C. (262.4 deg. F.). As a precaution against

FIG. 7.—DEVELOPMENT OF LONG JOINTED BACTERIA IN ALGÆ.

dust the linoleum which covered the floor was kept well oiled and the tables were moistened with a 25 per cent solution of glycerine in alcohol. During all operations which involved exposure of the cultures or liquids all the doors and windows were closed to prevent drafts and the operator wore a freshly-washed linen blouse. All such operations, furthermore, were performed under a screen which formed an additional safeguard against dust, and the flasks were sealed and opened with the aid of a naked flame.

Notwithstanding these elaborate precautions against the entrance of germs Dunbar found that the addition of certain chemicals to his pure cultures was followed, after a greater or less interval, which in some cases was as short as five days, by the occurrence of peculiar phenomena, in addition to changes of form, in the green alga cells. These phenomena included the vanishing of the green color, the appearance and multiplication within the cells of light-colored spherical bodies

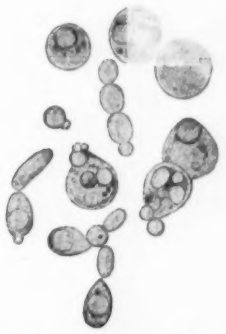


FIG. 8.—DEVELOPMENT OF YEAST CELLS FROM ALGÆ.

of high index of refraction, the rupture of the cell walls, the discharge of their contents, and the transformation of the latter into bacteria of various forms, including globular cocci, rod-like bacilli, spiral and sarcine or quadruplex forms, and into yeasts and molds with their characteristic textures and spores (Figs. 3 to 9).

The culture liquids generally used were bouillon with sugar, potato gruel with and without sugar, and a solution of ammonium sulphate. The chemical reagents included various alkalies, acids, and salts, the specific effects of which are detailed in Dunbar's description of the experiments.

Old cultures were found most suitable for the production of bacteria, as fresh cultures were injuriously affected, and in some cases killed, by the reagents. In general, bacteria were produced most abundantly by cultures originally poor in chlorophyl, and the tendency to form bacteria was increased by all reagents that destroyed the green color of the algæ. Many flasks containing cultures of algæ in an alkaline medium produced bacteria without receiving further additions or even being opened. In these cases the algæ never showed any green coloration.

Of 53 cultures treated with reagents in 1905, 33 produced bacteria, 6 produced molds and 14 were unaffected. Of 289 cultures treated in 1906, 134 produced bacteria, 27 produced molds, and 128 were unaffected. Of 142 cultures treated in 1907, however, only 28 pro-

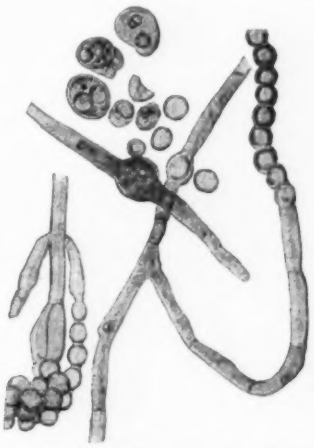


FIG. 9.—DEVELOPMENT OF MOLD FUNGI FROM ALGÆ.

duced bacteria and 3 produced molds, while 111 remained unchanged.

Summing the results of the three years, we find that bacteria or molds were formed in 231 of the 484 culture flasks which were treated with chemicals. As a rule, each of these flasks was opened twice for the addition of reagents, the whole number of openings being 512. 221 control flasks, containing the same culture liquids but no algæ, were treated in a similar manner, the whole number of openings averaging more than two to

a flask and aggregating 497, yet bacteria appeared in only seven and molds in only eight of these control flasks. Furthermore, the 253 cultures of algæ which did not generate bacteria or molds were opened about 800 times, an average of more than three times for each flask. In 173 of these flasks the algæ were found dead, so that only 80 of the 484 cultures of algæ that were treated failed to produce bacteria or molds, although they survived the treatment.

If Dunbar's conclusions are verified by other observers and if the bacteria-like objects generated by algæ are proved to be real bacteria (a point which Dunbar did not attempt to determine) a new light will be thrown on the origin of these lowly organisms, although their constancy of species, or type, will not be affected. The possibility of a higher species giving birth to numerous distinct lower species under the influence of particular chemical and physical agencies is an idea wholly new to biological science.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

THE GEOLOGY OF THE KLONDIKE.

GENESIS OF THE FORMATION OF GOLD IN THE PLACER GRAVELS IN THE KLONDIKE-YUKON MINING REGION. GEOGRAPHY OF THE KLONDIKE REGION. MINING OF GOLD PLACER GRAVELS IN KLONDIKE-YUKON VALLEY BY DREDGERS. COST OF EXTRACTING GOLD.

BY DR. WILLIS EUGENE EVERETTE.

Concluded from Supplement No. 1669, page 411.

GENESIS OF GOLD FORMATION IN AQUEOUS SOLUTIONS OF ALKALINE SILICATES.

THE formation of the alkalinely-silicated thermal water is accounted for as follows:

The sun, by its intense heat rays, warms the surface of the waters of the ocean, so that a portion of this water, by what is called evaporation, rises into the air in the form of a wet, vapory gas, and ascends to a plane or level in the air where the temperature is cooled sufficiently to condense this vapory gas back again into its original form of liquid water. The specific gravity of this drop of liquid water is such that it is attracted down to the earth along with myriads of other drops, and we then have the familiar representation of a precipitation of rain or dew.

Now, eliminating the amount of re-evaporation, and also any absorption of a part of this water by contact with the earth or organic matter, the penetration of this drop of water into the interior of the crust of the earth is attended with such a degree of heat—averaging 1 deg. F. for each 70 feet in depth—as again to change this liquid water into a vapory gas, but this ti.... into an intensely heated, very corrosive gas, due to contact with the continuously heated inter-terrestrial rocks. Water, under heat and pressure, is more corrosive in its action than even nitric acid, as water contains more oxygen than any known acid in the science of chemistry—nearly 90 per cent oxygen.

Granite is practically the basal rock of the earth, in so far as we actually know the composition of the interior, or the 1/4,000 part of the earth. Granite is composed of a mechanical conglomeration of oxygen, iron, silicon, and alkalies in the shape of quartz, felspar, and mica. The felspars are silicates of the alkalies, such as soda, potash, lime, magnesia, and lithia, the latter being rarely found in mass.

Water, when under pressure and intensely heated, is converted into an extremely corrosive oxidizing gas called superheated steam, and contains 88 per cent of oxygen; this is even more oxygen than has any acid known to the science of chemistry. Water, when changed into intensely superheated steam or water gas, has the power—due to the enormous amount of oxygen which it contains—to rapidly oxidize and dissolve the alkalies from the felspars in the granites. A solution of an alkali, thus formed, intensely heated and under great pressure, has the power of dissolving silica (quartz) as quickly as a lump of cube sugar is dissolved in hot water, in fact, even more rapidly.

We have now a hot aqueous solution of an alkaline silicate, from a combination of pressure, heat, water, and the alkali and quartz from a decomposed granite. A steamy or gaseous hot alkaline silicate, when under the proper conditions of pressure and temperature, has the power of interpenetrating the closest-grained and most dense rocks, and dissolving out any sulphur, iron, gold, silver, copper, or in fact any of the metalliferous elements contained therein, and converting them into unstable conditions, such as silicates, in chemical combination with one another with water.

Geologists and chemical analysts have abundant proofs that minute quantities of gold, sulphur, and iron are distributed in more or less quantity throughout the vast masses of metamorphic and altered rocks of the crust of the earth, even though no veins of silica (quartz lodes) containing gold and other minerals are in any close proximity.

There is thus, therefore, no want of the source of supply to obtain the gold, sulphur, and iron held in solution in the presumed aqueous alkaline silicate taken from even the basal granite itself, as well as from the metamorphic rocks.

The surface water of the earth, percolating through the detrital gravels and sediments of creek beds (as a general rule) has an acid reaction, due to the presence of ulmic, humic, and carbonic acids, resulting from the decomposition of decaying vegetation or oxidizing organic matter.

When an aqueous solution of an alkaline silicate comes into contact with acidulated waters, an immediate electro-chemical reaction takes place, and a precipitation of all excess of silica (quartz) is formed at once, together with the precipitation of all gold, sulphur, and iron that is in the solution.

This aqueous solution of hot alkaline silicates, forced upward by either plutonic or volcanic pressure, toward a point of its least resistance, was injected into the detrital matter overlying the bedrocks of the placer gold fields, and coming into contact with the downward-percolating, more or less acidulated waters from the muck and vegetation above, there precipitated its content of dissolved silica as quartz, the sulphur and irons as pyrites, and the metallic gold in grains, scales, and amporphous fragments; and thus, what is locally known as the "paystreak" was formed. The iron and sulphur combined as crystals and masses of iron pyrites. The gold was formed in grains, and in crystals of pseudomorphs after silica and pyrite; also as nuggets and small concentrically deposited masses interpenetrated with both pyrite and quartz, and was also chemically and mechanically combined with iron and copper pyrites, thoroughly impregnating the schistosic bedrocks with minute grains of very rich pyritic crystals, some of which, especially in the broken surface of the bedrocks of Upper Sulphur Creek, in 1898 showed values in gold as high as ten thousand dollars to the ton of pyrites. The percentage of these rich and excessively minute pyritic crystals averaged from two to five per cent of a ton of broken schist bedrock.

Therefore, the presence of crystals of solid gold in pseudomorph forms after silica, hematite, and pyrite, whose sharp angles were not bruised by any attrition, and the radiating plexuses of myriads of grains of irregular shaped and unworn concentrically deposited and unattrified gold, together with the minutely fine and extremely rich crystals of gold-bearing pyrite, in the bedrocks of the broken schists and siliceous sheared serpentines underlying the detrital deposits, most distinctly proves that, at least in some instances, the "igneous theory," of broken plutonic-formed veins of gold quartz as a gold deposition by torrential lixiviation will not hold true in every case; and that by the quiet and unseen agencies of internal heat and water, acting on the silica and felspars of the basal rocks, conditions are given which can cause gold-bearing, pyrite-bearing, and quartz-bearing deposits throughout formerly non-auriferous, non-pyritiferous, and non-siliceous detrital sediments, in and on the bedrocks of gold placer fields, more especially if the surface or upper portion of these bedrocks is broken with deep cleavage lines.

During my investigation of Eldorado Creek in 1898, I received information from a miner, who stated that the detrital matter lying on the surface of his bedrock is practically barren and worthless as a gold-bearing gravel; but that he is actually digging into and taking out seven feet of broken bedrock and finds it very rich in fragments of gold and minute crystalline quartz in all positions of deposition, interpenetrating among the cleavage lines of the former broken and upheaved laminated schist of the broken bedrock, especially in the "White Channel" bedrocks. Here again is a distinct proof of a deposition of gold and silica (silicate or quartz) from an aqueous alkaline silicate solution. I call close attention here to the possible "milling value" of the white channel gravels as a hard rock proposition. My 5,000 assays of this Klondike hard rock gave me an average value of $1.80 per ton, and a 50-ton milling test gave an average value of $2.07 per ton in gold. These are results to be thoroughly considered.

GEOGRAPHY OF THE KLONDIKE REGION.

Standing on the Dominion Dome (which is a high, rounded peak somewhat resembling the top of Pike's Peak from Cripple Creek in Colorado) the observer will notice that the Klondike region is in somewhat the position of an irregular square. The magnetic variation of the compass needle being 35 deg. east, the compass bearings which I here give will be true north. The Klondike region is bounded on the north by the Klondike River, on the west by the Yukon River, on the south by Indian River, and on the east by Flat Creek. The main gold-bearing stream north of the Dome is Hunker Creek, which flows north and northwest into the Klondike River.

On the left limit (or the left-hand side looking downstream from its source) are four large tributaries, all of which are gold-bearing, as well as the main stream, or Hunker Creek.

To the west, and flowing northwesterly into the Klondike River, is Bonanza Creek. Near its head this stream is forked into two creeks, namely, the Upper Bonanza Creek and Eldorado Creek. On certain bench claims along Bonanza Creek and several of its gulches and side creeks, notably near the confluence of Eldorado Creek and Upper Bonanza Creek, are some very rich gold-bearing placer beds, especially near the mouth and left limit hillsides of Eldorado Creek. South of the Dome are Nine Mile, Ophir, Quartz, Sulphur, Gold Run, and Dominion creeks, which flow into the Indian River. They all have tributaries and bench terraces which are more or less gold-bearing.

East of the Dome is Flat Creek and All Gold Creek. They flow into the basin of the Upper Klondike River, and are separated from the Indian River creeks by a high divide or mountain range.

To the far westward of the Dome is the Yukon River, flowing nearly north and south from Indian River to near the mouth of the Klondike River, at a short distance below the mouth of Swede Creek. The tributaries to the Yukon River are separated from the Bonanza Creek and Indian River tributaries by a high mountain range.

Thus the Dome seems to be an upheaval in the center of the gold-bearing district, from which the gold-placer streams radiate in all directions. The entire surface of the country is underlaid with frozen detritus, and it is covered with a thick growth of mossy bogs and spruce and birch forests to nearly the tops of the highest peaks and ridges. The valleys contain grassy bogs, with groves and thickets of poplar, cottonwood, willow, and rosebriers. The schists which outcrop on the Dome and on its ridges and attendant peaks show no evidence of any glaciation, but are sharply broken with inclined laminated jagged edges.

Toward the mouths of Sulphur and Dominion creeks and the Indian River the valleys are very wide, long, and level, showing undoubted evidence of their having been—previous to the emergence of the Dome—long and shallow mountain lakes. At present they are great peat bogs, overlying a frozen mass of muck and detrital gravels.

METHODS OF MINING IN THE KLONDIKE REGION.

The prevailing method of individual winter mining in the Klondike region is first to strip the moss from the surface of the frozen ground and build fires of split wood to thaw the frozen muck and gravel down to the bedrock; then fires (of split dry wood covered with green wood) are built against the face of the frozen gravels on the bedrock, which gravels when thawed are hoisted to the surface, and formed into a huge conical pile of debris, to remain until the next summer, when flowing water can then be obtained in sufficient quantity to wash the gold from this heap of

thawed gravel, either in a line or string of sluice boxes by gravity, or by hand agitation with rockers.

Steam thawing of the frozen gravel is being successfully employed, by injecting steam under pressure through a long hollow pipe, driven as a drill into the gravel, and allowing the steam to escape at the point of the hollow pipe for several hours. This method is simple, economical, does not give any smoke or poisonous fumes, and thaws the pay gravel without at the same time thawing very much of the worthless overburden or barren gravel and muck. After every "heat" or "thaw" the miner usually washes several pans of his gravel, to ascertain if it continues to be gold-bearing, and thus enable him to "follow his pay streak. The pay gravel is thrown into what is called the pay dump, and the barren gravel and muck is thrown into what is called a waste dump.

Hot-water thawing of the frozen gravel has also been used with more or less success. This method of thawing is by the pressure of steam on boiling hot water direct from a boiler, and forced through a hollow steel-tipped pipe, driven as a drill deeply into the frozen gravel. The thawed gravel is then extracted, hoisted, and treated the same as when steam is used.

Kerosene and gasoline thawing of the frozen gravel, by direct application of a continuous blast of flame, under powerful air pressure, from a tank of kerosene or gasoline, has not proved to be satisfactory; for these oil burners nearly always become choked with precipitated carbon as soot, and they do not give economical results, and are poisonous with their carbonic acid fumes when working underground.

Hydraulicking and dredging the gold placer gravels, by the usual mining methods, is also being used. But while the dredger can excavate and scrape out the frozen gravel, the finely-crushed frozen gravel and sediments will not lixiviate well enough in the sluice boxes to economically save all the gold therein, so that, even with dredge mining of these Klondike gravels, it is advisable to keep the steam points ahead of the dredger in the frozen gravel, and thus have a supply of thawed gravel for the dredger to work upon. In hydraulic mining with a very long line of sluice boxes, it may be possible that the attrition of the gravel in the boxes may thaw the hydraulically torn out frozen gravel, and thus be able to save the gold therefrom without previously being compelled to thaw and melt the icy frozen gravel.

The vast amount of fine gold and flour gold and gold-bearing pyritic sands (which are usually lost by the present hand methods of sluicing out the gravels) can undoubtedly be saved by a proper system of sluice riffles and undercurrents alongside and adjacent to the line of sluice boxes, and passing these slimes over a certain class of economic concentrators.

With hydraulic power there are enormous quantities of gravel in the Klondike region that will richly repay the investment of such installations, and the combined electric conveyor, bedrock sump, and hydraulic ground sluice to an overhead flume will be the working methods of the future in these northland gravels.

REPORT OF DREDGING OPERATIONS IN GOLD PLACERS IN THE VALLEYS OF THE KLONDIKE AND YUKON RIVERS.

In 1899 (to a London syndicate, who were then about to invest $400,000 in dredging the Klondike gravels for gold) I reported adversely in regard to the economic workings of the auriferous gravels by the method of dredging operations in the valleys of the Klondike, Yukon, Stewart, and Indian rivers.

A change of climatic and local working conditions has somewhat modified my views on the subject of economically dredging the Klondike auriferous gravels, and I am now satisfied to report that, under certain necessary conditions of location and transportation, quite economical and profitable dredging operations may be conducted over certain areas of the Klondike region.

In 1901 a small dredger was installed on a gravel bar in the Yukon River, at a point called Cassiar Bar, which did not prove to be a financial success.

In 1902 a small dredger was installed on the gravel bars of the Middle Stewart River. This, also, was a financial failure.

In 1903 the Lewes River Dredging Company installed a 750-cubic-yard dredger on Bonanza Creek, near to and below the mouth of Eldorado Creek. The success of this venture was such that capital has been attracted to the financial results of its dredging operations; and very large areas—miles in extent—of the creeks of the Klondike region have been purchased at enormous prices by both American and English mining financiers. The success of this first dredger on Bonanza Creek was the direct means of showing a practical method whereby the gold content of the frozen auriferous gravels could be economically obtained by dredging operations. The "dredging fever" is now at such a high temperature in the Klondike region, that if one hundred dredgers could be obtained from the manufacturers for the year 1907, the entire consignment would be immediately purchased and installed for dredging operations by the owners and operators of gold-bearing gravel deposits in these Klondike-Yukon gold fields. The success of this first dredger on Bonanza Creek was quite remarkable, owing to the fact that it had first to remove from three to eight feet of muck or a peaty vegetable mold that was non-auriferous and frozen. Afterward the uncovered frozen gravel was thawed by means of steel thawing points driven by hand labor into the frozen mass, and connected with long flexible steam pipe lines attached to a boiler of large capacity, the hot and wet steam under pressure passing through these lines and sweating the frozen gravels to about three feet in all directions from the ends of the thawing points. The thawed gravel would now be removed by the dredger, and the same process repeated until solid and unbroken bedrock was reached. All this had to be done ere the gold could be extracted from the gravel. At the end of this report will be found a cost sheet of the detailed daily expenses of actual operations of one of these Klondike-Yukon dredgers. A large amount of fuel is consumed in these dredging operations; the cost of wood is $12 to $15 a cord, an earthy form of lignite coal from $15 to $20 a short ton, and electric energy can be obtained at 5 cents per kilowatt hour.

Notwithstanding all these local adverse conditions, this first dredger on Bonanza Creek made a sufficient financial success to demonstrate to mining capitalists that the frozen auriferous gravels of certain sections of the creeks of the Klondike-Yukon region could be profitably operated by dredges—more especially if cheap power from electric energy could be purchased.

In 1905 the dredger that had been on Stewart River was installed in the Klondike River, about one mile above its confluence with the Yukon River; and were it not for broken links of its main chain cable having to be repaired under great local difficulties and consequent waste of valuable time in the dredging season, this dredger would have been operated profitably.

In 1905 the Canadian-Klondike Mining Company of Detroit secured about eight miles of a former concession in the valley of the Klondike River, beginning about two miles upstream from its junction with the Yukon River. This company installed a large dredger of 3,000 cubic yards daily capacity in the Klondike Valley at the mouth of Bear Creek, and has made a financial success. So satisfactory were the results of the operations of this dredger, that the company has placed orders for the immediate manufacture of three more dredgers of similar size to the one it is now operating; two of which dredgers it hopes to have on the ground and in actual operation for the late summer workings of 1907 or season of 1908.

In 1906 the Bonanza Basin Gold Mining Company installed a large dredger in the Klondike River, about a half mile upstream from its mouth. The profitable result of their first season's work has been so great that this company has a second dredger under construction and is trying to have it installed for operation during the season of 1907.

In 1906 the Canadian Forty Mile Company had installed on the Forty Mile River, on its concession of twenty miles of the bed of the said river (or from the shore line of the Yukon River up the valley of the Forty Mile River to the United States boundary line) a large Allis-Chalmers dredger of 3,000 cubic yards daily capacity, and expects to have several other dredgers installed on the same river as soon as it can obtain them from the manufacturers.

In 1906 the Yukon Gold Fields Mining Company (which is a subsidiary branch company of the Guggenheim Exploration Company of New York) having purchased about 25 miles of creek mining ground, began the installation of three large dredgers on Bonanza Creek, and also in the Klondike Valley at the mouth of Bonanza Creek. It has been publicly stated that this company intends to continue installing large dredgers until it has twelve to fifteen dredgers in operation in the Klondike region.

The class of dredger that is being installed by this company will be operated by electric power. A generating electric power plant for producing electric energy is now being installed by this company on the Twelve Mile River, or at about 30 miles from where the dredgers will begin operations. This electric energy will be transmitted by overhead wires at a high voltage for 25 miles, and the pressure let down by local transformers to the several dredgers. A large dam has been built on the Twelve Mile River, and Pelton wheels will be used to take up the energy of the falling water, and then transfer this energy to the dynamos. This company has already expended over three millions of dollars in cash in the Klondike-Yukon section, and has contracted itself to expend many millions more in this mining region of the Northland.

In 1906 two dredgers of the dipper-type pattern were taken up the Forty Mile River into the Alaska Territory, or on the American side of the boundary line. This type of dredger is to be used only temporarily, until a modern type of bucket dredger can be obtained. I do not believe that the dipper-type of dredger will be of any practical use in working the gravels of this frozen Northland region.

In 1906 an American company commenced the construction of a bucket dredger in the valley of the Forty Mile River on the Alaska side of the boundary line.

In 1906 an English company landed a large dredger at the mouth of the Forty Mile River, for transportation to their group of claims on Walker's Fork, a tributary of the said river. This group of claims is on the Alaska side of the boundary line. This dredger will weigh about 350 tons, and will have to be hauled in small sections on sleds over 100 miles on the ice and snow to its destination before it can be installed for working operation. The confidence reposed in the values of this proposition affords a significant indication for the reasons of going to the great preliminary expenses of installing this particular dredger for operation.

In 1906 there were seven other mining operators who were negotiating and trying to obtain modern type dredgers for their several properties. One of these companies owns the Robertson concession on the Yukon Valley at the mouth of the Forty Mile River, and this company arranged to install a dredger on its ground during the season of 1907.

Up to October 1, 1906, there were eight dredgers in actual operation and under construction in the valleys and tributary streams of the Yukon, Klondike, and Forty Mile rivers; and eleven dredgers contracted for to be installed during the year of 1907.

(NOTE.—Up to December, 1907, the Guggenheim Company had installed three more huge dredgers during the summer of 1907, and there are now known to be ten dredgers in operation and fifteen dredgers contracted for.)

Attention is called to the cost sheet of the actual daily expenses of practical operations in dredging the frozen gravels of the Klondike-Yukon mining region.

CLIMATIC AND ADVERSE CONDITIONS IN DREDGING OPERATIONS IN THE KLONDIKE-YUKON MINING REGION.

1. Frozen gravel and frozen paystreaks in broken bedrock.

2. Barren and frozen overburden of muck and peat, which must be thawed by either ground sluicing or by steam points, and then taken off by horse or steam scrapers, or else thawed by the steam points and dug up by the dredger and passed through the machine without any returns of values.

3. Cost of wood for fuel, at $[illegible] to $15 per cord; lignite coal, at $15 to $20 per ton; electric energy at 5 cents per kilowatt hour.

4. Dredging season in the Yukon Klondike region, at the normal maximum length, is from May 1 to [illegible] 1 of nearly 24 hours of continuous daylight and flowing water each day. The normal minimum length of the open season is from May 10 to September 15 of unfrozen surface ground and flowing water.

5. Minimum cost of unskilled labor, at $4 a day and board. Normal wages for skilled labor, at $5 to $15 a day and board.

ACTUAL COST OF WORKING OPERATIONS IN DREDGING IN THE KLONDIKE.

This dredger has a daily capacity of 2,000 to 2,500 cubic yards in 24 hours. For frozen gravel, an average maximum cost of 80 cents per cubic yard. For unfrozen gravel, an average maximum cost of 20 cents per cubic yard.

In hydraulic workings, the cost of operations is very much cheaper, because the summer sunshine is used to thaw the banks of gravel, and an enormously greater amount of gravel can be torn out of a bank by a hydraulic nozzle and then hydraulicked in a given time than can be dug up by a dredger and be lixiviated by means of the ordinary sluices of a dredger floating in a pond of water on a scow.

The cost of thawing the gravel when frozen is from 25 cents to 60 cents per cubic yard. This cost is to be added to the additional cost of extraction by the buckets of the dredger, and the lixiviation of the said thawed gravel in the sluices on the scow.

DAILY EXPENSE ACCOUNT OF THREE EIGHT-HOUR SHIFTS PER 24 HOURS.

1 Managing engineer and superintendent, $25 a day and board at $2 a day	$27.00
1 Foreman, $10 a day and board at $2 a day	12.00
3 Winchmen, $8 a day and board at $2 a day	30.00
3 Engineers, $8 a day and board at $2 a day	30.00
3 Oilers, $6.50 a day and board at $2 a day	25.50
4 Deck hands, $6 a day and board at $2 a day	32.00
2 Blacksmiths, $7 a day and board at $2 a day	18.00
2 Gold dust cleaners, $7 a day and board at $2 a day	18.00
1 Cable lineman and electrician, $8 a day and board at $2 a day	10.00
1 Shore hand, $6 a day and board at $2 a day	8.00
2 Cook and helper, $6 and $3 a day and board at $2 a day	13.00
1 Bookkeeper, $8 a day and board at $2 a day	10.00
1 Team and driver, $8 a day and board at $2 a day and $3 for board of the team	13.00
Supplies and Repairs.—(Average about $50 per 24 hours)	50.00

Fuel for Boilers.—Cordwood at $17 per cord;
Electric power at 5 cents per kilowatt hour.
(This dredger uses 2,250 kilowatts at 5 cents per kilowatt hour) 112.50

Daily average cost of operation, $409.

Daily average cost of extraction, 25 per cent of the gross output of the gold.

Daily average output of gravel, 2,000 to 2,500 cubic yards.

Daily average value of the gravel, including overburden to bedrock, 80 cents per cubic yard.

Daily average cash profit, $1,300 to $1,500.

A very much smaller dredger, of only 700 cubic yards daily capacity, costs $200 a day to maintain and operate; but working on very much richer gravel, it makes a greater daily equivalent profit. This smaller dredger has to thaw its frozen gravel, by means of hollow steel-tipped pipes driven into the frozen gravel, and live steam forced therein, at a total cost of 80 cents per cubic yard.

A FLYING MACHINE FOR THE ARMY.

SPECIFICATIONS PUBLISHED BY THE SIGNAL CORPS FOR THEIR CONSTRUCTION.

TO THE PUBLIC:

Sealed proposals, in duplicate, will be received at the office of the Chief Signal Officer until 12 o'clock, noon, on February 1, 1908, on behalf of the Board of Ordnance and Fortification, for furnishing the Signal Corps with a heavier-than-air flying machine. All proposals received will be turned over to the Board of Ordnance and Fortification at its first meeting after February 1, for its official action.

Persons wishing to submit proposals under this specification can obtain the necessary forms and envelopes by application to the Chief Signal Officer, United States Army, War Department, Washington, D. C. The United States reserves the right to reject any and all proposals.

Unless the bidders are also the manufacturers of the flying machine, they must state the name and place of the maker.

PRELIMINARY.

This specification covers the construction of a flying machine supported entirely by the dynamic reaction of the atmosphere and having no gas bag.

ACCEPTANCE.

The flying machine will be accepted only after a successful trial flight, during which it will comply with all requirements of this specification. No payments on account will be made until after the trial flight and acceptance.

INSPECTION.

The government reserves the right to inspect any and all processes of manufacture.

GENERAL REQUIREMENTS.

The general dimensions of the flying machine will be determined by the manufacturer, subject to the following conditions:

1. Bidders must submit with their proposals the following:

(*a*) Drawings to scale showing the general dimensions and shape of the flying machine which they propose to build under this specification.

(*b*) Statement of the speed for which it is designed.

(*c*) Statement of the total surface area of the supporting planes.

(*d*) Statement of the total weight.

(*e*) Description of the engine which will be used for motive power.

(*f*) The material of which the frame, planes, and propellers will be constructed. Plans received will not be shown to other bidders.

2. It is desirable that the flying machine should be designed so that it may be quickly and easily assembled and taken apart and packed for transportation in army wagons. It should be capable of being assembled and put in operating condition in about one hour.

3. The flying machine must be designed to carry two persons having a combined weight of about 350 pounds, also sufficient fuel for a flight of 125 miles.

4. The flying machine should be designed to have a speed of at least 40 miles per hour in still air, but bidders must submit quotations in their proposals for cost depending upon the speed attained during the trial flight, according to the following scale:

	Per cent.
40 miles per hour	100
39 miles per hour	90
38 miles per hour	80
37 miles per hour	70
36 miles per hour	60
Less than 36 miles per hour, rejected.	
41 miles per hour	110
42 miles per hour	120
43 miles per hour	130
44 miles per hour	140

5. The speed accomplished during the trial flight will be determined by taking an average of the time over a measured course of more than five miles, against and with the wind. The time will be taken by a flying start, passing the starting point at full speed at both ends of the course. This test subject to such additional details as the Chief Signal Officer of the Army may prescribe at the time.

6. Before acceptance a trial endurance flight will be required of at least one hour during which time the flying machine must remain continuously in the air without landing. It shall return to the starting point and land without any damage that would prevent it immediately starting upon another flight. During the trial flight of one hour it must be steered in all directions without difficulty and at all times under perfect control and equilibrium.

7. Three trials will be allowed for speed as provided for in paragraphs 4 and 5. Three trials for endurance as provided for in paragraph 6, and both tests must be completed within a period of 30 days from the date of delivery. The expense of the tests to be borne by the manufacturer. The place of delivery to the government and trial flights will be at Fort Myer, Virginia.

8. It should be so designed as to ascend in any country which may be encountered in field service. The starting device must be simple and transportable. It should also land in a field without requiring a specially prepared spot and without damaging its structure.

9. It should be provided with some device to permit of a safe descent in case of an accident to the propelling machinery.

10. It should be sufficiently simple in construction and operation to permit an intelligent man to become proficient in its use within a reasonable length of time.

11. Bidders must furnish evidence that the government of the United States has the lawful right to use all patented devices or appurtenances which may be a part of the flying machine, and that the manufacturers of the flying machine are authorized to convey the same to the government. This refers to the unrestricted right to use the flying machine sold to the government but does not contemplate the exclusive purchase of patent rights for duplicating the flying machine.

12. Bidders will be required to furnish with their proposal a certified check amounting to 10 per cent of the price stated for the 40-mile speed. Upon making the award for this flying machine these certified checks will be returned to the bidders and the successful bidder will be required to furnish a bond, according to Army Regulations, of the amount equal to the price stated for 40-mile speed.

13. The price quoted in proposals must be understood to include the instruction of two men in the handling and operation of this flying machine. No extra charge for this service will be allowed.

14. Bidders must state the time which will be required for delivery after receipt of order.

JAMES ALLEN, Brigadier General,
Chief Signal Officer of the Army.

Signal Office, December 23, 1907.

ENGINEERING NOTES.

Glass telegraph poles are to be manufactured in a factory recently built at Grossalmerode, Germany. An architect of Cassel has been granted patents in Germany and other European countries and in the United States for a machine to be used in their manufacture. The glass is reinforced by wires suitably disposed. These poles, it is believed, will be particularly adapted for use in countries where wooden poles are quickly destroyed by insects or climatic conditions. The Imperial Post Department of Germany has ordered these poles for use on one of its telephone or telegraph lines.

A mishap, fortunately attended by no serious consequences, recently occurred during an ascent of the French dirigible balloon "Patrie." She left Chalais-Meudon, says the Army and Navy Gazette, and on passing over Issy-les-Moulineaux the screw suddenly became detached and fell into a brickyard below. The "Patrie" immediately rose to a great height but descended safely at Fresnes-les-Rungis. This incident, like that which occurred in the case of the Aldershot airship, shows that untoward incidents may be expected with such frail constructions, and it is fortunate when they are attended by no serious consequences.

To drilling of bolt holes in partially green concrete is a tedious process, says a contemporary, owing largely to the frequent wedging of the drill. One contractor seems to have hit upon a simple method of drilling these holes without undergoing the delay incident to wedging. He uses a compressed air drill hung in the guides of a small pile-driver frame, the drill occupying the same position as would the hammer in pile-driving. The drill is suspended by a wire rope, and raised or lowered by means of a hand windlass. One advantage of this arrangement is that a longer drill can be used than with the ordinary tripod outfit. A small metal pipe is carried with the drill into the hole, and through this water is forced under a heavy pressure, carrying off the chips, and thus preventing all tendency to wedge. Many such holes have been bored in partially green concrete to a depth of over 6 feet.

TRADE NOTES AND FORMULÆ.

Indelible Ink.—Add to a slightly acidulated nut-gall ink an equal volume of a solution of 1 part of nitrate of silver in 10 parts of water and then a similar quantity of India ink rubbed up in water.

Rubber Lubricant.—Train oil 200 parts, rubber 20 parts. The train oil is heated in a kettle until decomposition commences (which can be recognized by its bubbling up and the unpleasant odor). The rubber is then gradually added in small pieces, the whole mass being thoroughly stirred after each addition.

Printing Rollers for Calico Printing.—(*a*) Antifriction metal tincture 14 parts, antimony 80 parts, copper 5 parts, nickel 1 part. (*b*) Tin 16 parts, antimony 78 parts, copper 6 parts. (*c*) According to analysis: Tin 15.8 parts, zinc 78.3 parts, copper 5.6 parts.—Bersch.

Painting Signs on Wire Gauze.—Before outlining the lettering, the gauze should be painted with a decoction of Iceland moss. This slimy substance connects the separate wires and produces a continuous surface, on which the work is done in the ordinary manner. When the color is dry, the superfluous substance is removed by washing.

Dultschaza are Oriental fruit preserves; 1 part by weight of sugar is dissolved in a little water, skimmed, and boiled until ropy. The fire must not be very hot, so that the sugar will not be browned; 1 part of pitted fruit is added; allow to boil up twice, and take the fruit out with a strainer spoon. After the syrup has been boiled down until quite thick and has had a chance to cool, it is poured over the fruit in jars.—Bersch.

To Stain Bone Brown.—The object must be freed from grease with the acid of petroleum ether, and for five to fifteen minutes must be left, at ordinary room temperature, in a mixture of 40 parts of hydrochloric acid with 1,000 parts of water, washed off with water, and placed in a solution of 5 parts of permanganate of potash in 1,000 parts of water. After coloring has taken place, the object must be removed, washed off with water, and when dry polished. If a more reddish color is desired, the object, before polishing, should be placed in a solution of 10 parts of fuchsine or grenadine in 1,000 parts of water.

Egg Albumen, Transparent, Alkaline, in the Form of Solid Jelly.—Raw hens' eggs are treated for several days with a 2 to 20 per cent potash or soda lye at a temperature of 104 deg. to 122 deg. F., then boiled hard in water. This makes the egg albumen completely gelatinous and transparent, so that the yolk shows through it. (This can also be accomplished by laying the egg in a paste of ashes or soda and caustic lime.) The alkalized egg albumen thus obtained, known as total albumen, is washed out in water and dried and is available, with vegetables, for use in bouillon. This albumen can also be preserved in 40 per cent alcohol, when used, it is boiled in water, allowed to swell, and sugar, cognac, or aromatic substances added to it. Alkalized and hard-boiled eggs may be preserved in ashes or dry bran, if kept cool, for a long time, and when used are separated from the yolk and treated like the egg albumen preserved in alcohol.—Bersch.

Lettering on Glass Plates.—The words should be set up in the desired style and size of type, and several impressions made on transparent paper. One of the impressions should be placed with its back to the glass and lightly attached to it at the edges. From the other sheets the letters should be separately and neatly cut and stuck on the glass, with the printed surface in contact with it. The paste used for this purpose may be mixed with color resembling that of the printing. The lettering showing through to the other side, gives the right position for the lettering to be applied. Air bubbles must be well rubbed out, or, if necessary, pricked open with a needle. When the letters pasted on are dry, all the paste adhering to the polished glass is removed with the aid of a clean cloth. To secure the letters zinc white is rubbed down with thin linseed oil varnish to make a paint, with which the surface, including the back of the letters must be painted over. When everything is dry, the center sheet is removed and the lettering appears in black, red, blue, or parti-colors on a gray background.—Bersch.

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